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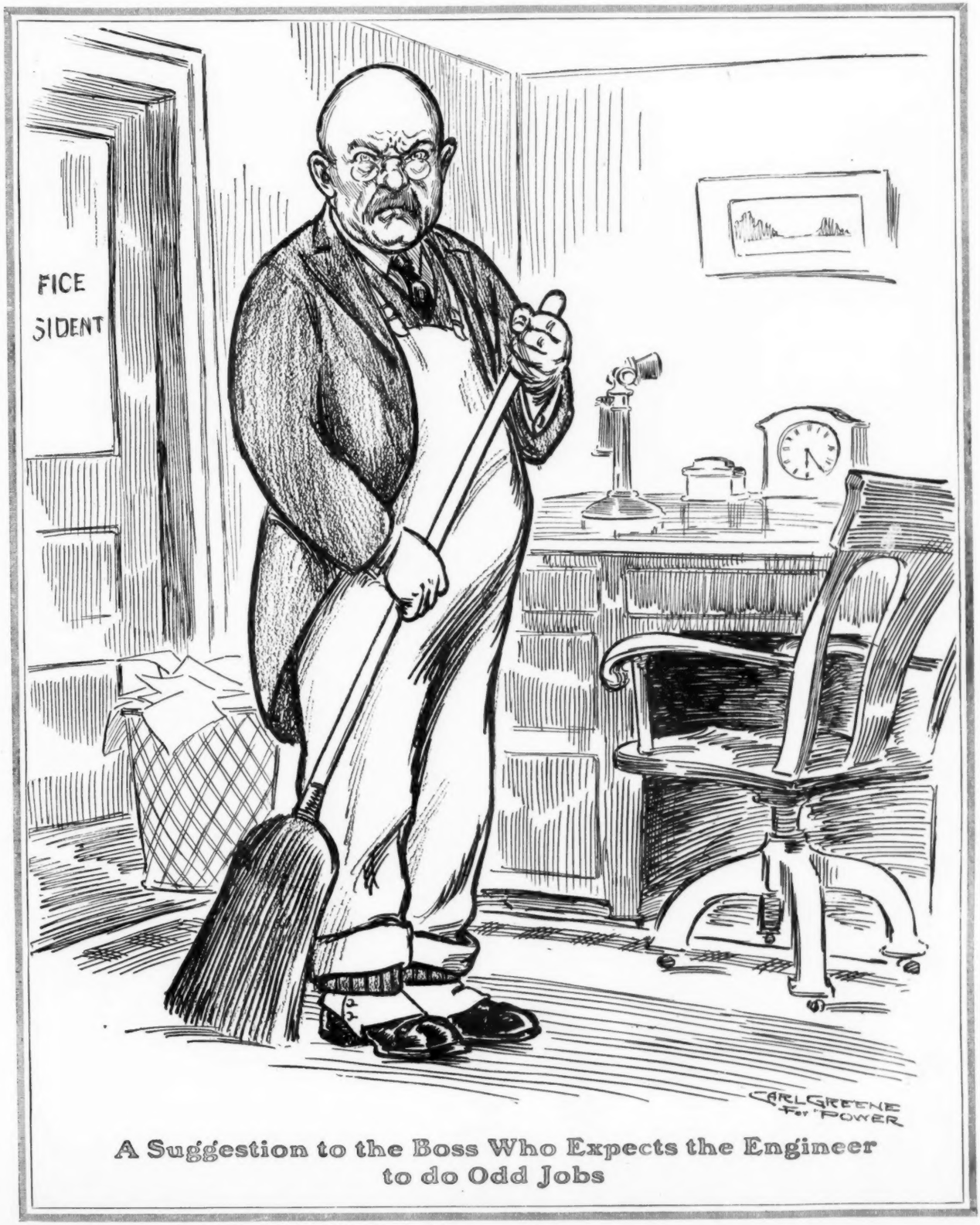
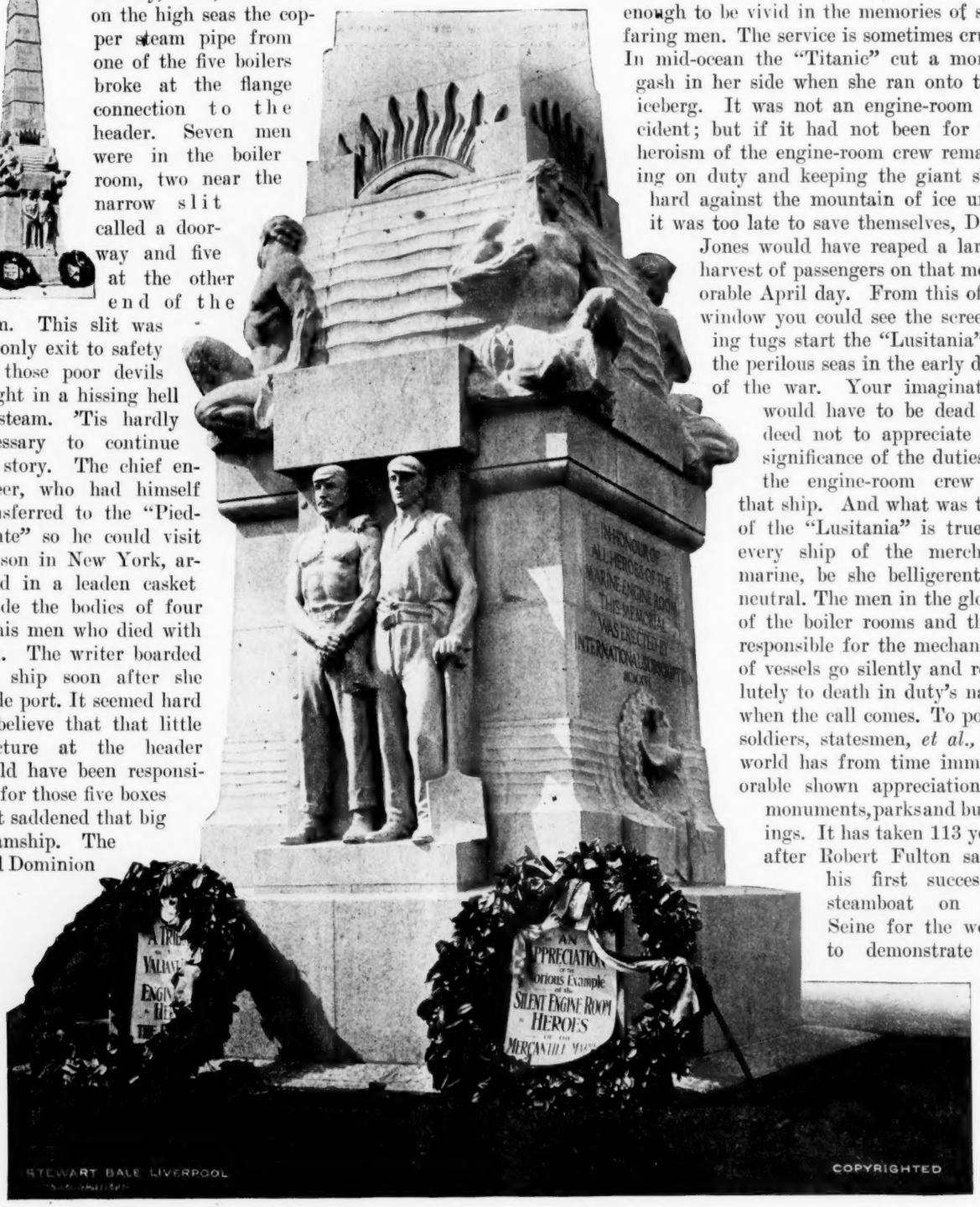


A Suggestion to the Boss Who Expects the Engineer to do Odd Jobs

Monument at Liverpool in

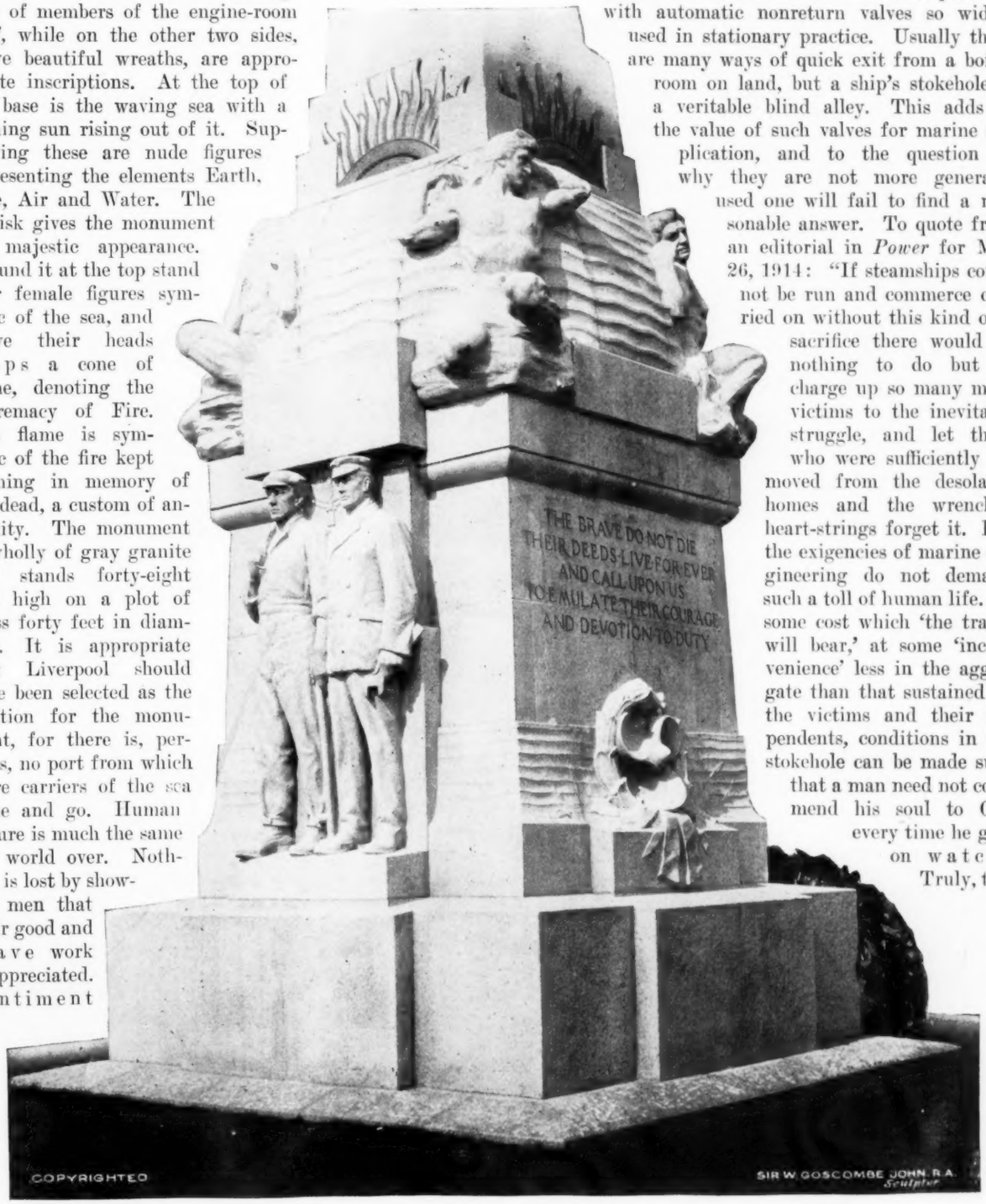
THE romance of the sea is fraught with pathos. The "Principe di Piedmonte" is an Italian liner. She left Naples early in July, 1912, and when on the high seas the copper steam pipe from one of the five boilers broke at the flange connection to the header. Seven men were in the boiler room, two near the narrow slit called a doorway and five at the other end of the room. This slit was the only exit to safety for those poor devils caught in a hissing hell of steam. 'Tis hardly necessary to continue the story. The chief engineer, who had himself transferred to the "Piedmonte" so he could visit his son in New York, arrived in a leaden casket beside the bodies of four of his men who died with him. The writer boarded the ship soon after she made port. It seemed hard to believe that that little fracture at the header could have been responsible for those five boxes that saddened that big steamship. The Old Dominion liner "Jefferson" was ploughing sturdily through the rough seas off Cape Henry on the night of May 11, 1914, when the crown-sheet of one of her boilers bagged and pulled the tube sheet away from twenty-four tubes. Death's toll was eleven. And what a death each must have had! These terrible accidents to engine-room crews at sea recall those of the "St. Paul," "Sonoma," "Alamo" and others in the mercantile marine recent enough to be vivid in the memories of seafaring men. The service is sometimes cruel. In mid-ocean the "Titanic" cut a mortal gash in her side when she ran onto that iceberg. It was not an engine-room accident; but if it had not been for the heroism of the engine-room crew remaining on duty and keeping the giant ship hard against the mountain of ice until it was too late to save themselves, Davy Jones would have reaped a larger harvest of passengers on that memorable April day. From this office window you could see the screeching tugs start the "Lusitania" to the perilous seas in the early days of the war. Your imagination would have to be dead indeed not to appreciate the significance of the duties of the engine-room crew of that ship. And what was true of the "Lusitania" is true of every ship of the merchant marine, be she belligerent or neutral. The men in the gloom of the boiler rooms and those responsible for the mechanism of vessels go silently and resolutely to death in duty's name when the call comes. To poets, soldiers, statesmen, *et al.*, the world has from time immemorable shown appreciation in monuments, parks and buildings. It has taken 113 years after Robert Fulton sailed his first successful steamboat on the Seine for the world to demonstrate in its orthodox way its recognition of the brave dead of the engine rooms of merchant ships. This beautiful monument, three views of which are shown on these pages, is from a world-wide subscription. It stands at Princes



FRONT OF MONUMENT, STANDING FIGURES REPRESENTING FIRE-ROOM FORCE

Honor of Marine Engineers

Pier Head near the dock at Liverpool, where passengers from Atlantic liners pass. The monument is the work of Sir William Goscombe John. Referring to the base, there stand on each of two sides figures of members of the engine-room staff, while on the other two sides, above beautiful wreaths, are appropriate inscriptions. At the top of the base is the waving sea with a flaming sun rising out of it. Supporting these are nude figures representing the elements Earth, Fire, Air and Water. The obelisk gives the monument its majestic appearance. Around it at the top stand four female figures symbolic of the sea, and above their heads leaps a cone of flame, denoting the supremacy of Fire. The flame is symbolic of the fire kept burning in memory of the dead, a custom of antiquity. The monument is wholly of gray granite and stands forty-eight feet high on a plot of grass forty feet in diameter. It is appropriate that Liverpool should have been selected as the location for the monument, for there is, perhaps, no port from which more carriers of the sea come and go. Human nature is much the same the world over. Nothing is lost by showing men that their good and brave work is appreciated. Sentiment inspires the soul. Heroes are always worshiped. But as one contemplates this beautiful memorial he cannot, especially if he is an engineer, but wonder how many brave lives have been wantonly sacrificed to duty whose real name was negligence. Several items on that long list of fatalities of the sea are broken steam pipes and fractured boilers. For some reason, likely custom and sentiment, most steam vessels are not provided with automatic nonreturn valves so widely used in stationary practice. Usually there are many ways of quick exit from a boiler room on land, but a ship's stokehole is a veritable blind alley. This adds to the value of such valves for marine application, and to the question of why they are not more generally used one will fail to find a reasonable answer. To quote from an editorial in *Power* for May 26, 1914: "If steamships could not be run and commerce carried on without this kind of a sacrifice there would be nothing to do but to charge up so many more victims to the inevitable struggle, and let those who were sufficiently removed from the desolated homes and the wrenched heart-strings forget it. But the exigencies of marine engineering do not demand such a toll of human life. At some cost which 'the traffic will bear,' at some 'inconvenience' less in the aggregate than that sustained by the victims and their dependents, conditions in the stokehole can be made such that a man need not commend his soul to God every time he goes on watch." Truly, this imposing monument insures to the memory of those honored dead of the engine-room crew a well though silently earned place in the heart of public appreciation. Brave deeds in times of peace also have their victories.



REAR OF MONUMENT, STANDING FIGURES REPRESENTING ENGINE-ROOM FORCE

Selecting Coal for the Plant

By George C. Cook*

SYNOPSIS—Points out what classes of fuels are most suitable for use with certain types of stokers, and consideration that should be given to the availability of a coal, deterioration in transit, kinds of grate, and local smoke ordinances.

To one who has not given the subject serious consideration it is somewhat surprising how varied and widespread are the factors that influence the choice of a suitable fuel. In general these factors are: The market conditions, the character and type of boiler-room equipment, the load and service requirements, the boiler-room personnel, and the requirements as to smoke.

In studying the local fuel market all available fuels should be given careful consideration, only excepting those that are obviously unsuited to the plant in question. A careful investigation should be made of the ability of the mine operator or dealer to furnish a supply uniform in quality and in sufficient quantity to meet the demands of the plant, also of the ability of the fuel to stand shipment, as some coals, notably the sub-bituminous coals and lignites, suffer marked deterioration in handling. Where conditions are such that it is necessary to carry a large reserve supply, the coal selected should be as free as possible from a tendency to spontaneous combustion. Coals most subject to this danger are the sub-bituminous coals, lignites, and bituminous coal when in a finely divided state.

Factors That Influence Price of Fuel

There are three general factors that enter into the price of fuel at any given plant—price at the mine, cost of transportation (rail or water) and cost of hauling or rehandling. In comparing prices of various fuels the price delivered at the plant in the storage pile or bunker, as the case may be, should be used as the basis of comparison, since coals shipped from certain points may be liable to additional charges for switching, hauling, etc.

The coal selected must be of a character adapted to the type of equipment used, as a fuel that might give excellent satisfaction with one type of equipment would be unprofitable used with equipment of a different type. A furnace designed with a small volume of combustion space or short flame travel before striking the heating surface is not adapted to burning high-volatile coals at high rates of combustion because of the probable loss from incomplete combustion and the emission of dense smoke. Furnaces having a tile roof or dutch oven are usually well adapted to burning the higher-volatile coals because of the increased combustion space they provide, and the maintaining by the heated brickwork of a high ignition temperature. Frequently various arrangements of arches, brick piers, wing walls, etc., are provided in the combustion space to facilitate complete combustion, when burning high-volatile coals, by effecting a more thorough mixture of the air and combustion gases. These devices are more or less effective according to the skill used in their design. In hand-fired furnaces, plain bar grates are used with the larger sizes or with coals that produce considerable clinker, while herringbone or pinhole grates are used with the finer sizes and with the free-burning coals.

Shaking and dumping grates require less labor in cleaning and consequently may be used with the higher-ash coals. In stoker installations it should be borne in mind that any type of stoker does not burn all classes of coal with equal facility, and that that kind of coal should be selected which will be best suited to the stoker installed. For instance, highly coking, low-ash coals are not suited to the chain grate, which is best adapted for burning the free-burning, high-ash bituminous coals of the Middle West.

Another feature that bears on the type of coal selected is the available draft at the plant. Where the draft is low, the larger sizes of coal of the free-burning type should be used. Coals that require a high draft are lignites, sub-bituminous and the fine sizes of anthracite. In general those characteristics of a coal which affect the amount of draft required for its combustion are size, coking qualities, ash content and clinkering properties. Where manual labor is used in the handling of the coal and refuse, low-grade high-ash coals will greatly increase the labor costs due to the increased quantity of material to be handled. This, of course, does not apply so fully to plants that have conveying systems or other types of coal- and ash-handling machinery. Plants having a steady load and a low rate of combustion usually have little difficulty in obtaining a coal that will be satisfactory. However, a plant having a steady load and a high rate of combustion or a fluctuating load with heavy peaks will have difficulty burning a coal whose ash-fusion temperature is low, since with a high rate of combustion the furnace temperature is usually high and trouble will be had from clinker.

Dirt in Coal Is Detrimental

Much of the credit for the success or failure of a coal is dependent upon the skill of the operating force. Intelligent high-grade men in the fireroom, well versed in the principles of combustion, can obtain good results with the lower-grade coals, while with the ignorant firemen, poorly paid and with little interest in their work, it is often necessary to use a so-called "foolproof" coal to insure continuity of service.

In the power plants used in connection with certain industries, the cleanliness of the fuel used is a factor that must be given consideration, as contamination of the product by coal dust would be detrimental. Where a plant is located in a city having a stringent smoke ordinance, care must be taken that the fuel selected can be burned with the existing equipment without causing violations of the ordinance. With high rates of combustion and high drafts, the emission of cinders is often considerable and in thickly populated districts constitutes a serious nuisance. Where this is the case, the coal should be selected with a view to minimizing the cinder production as much as possible.

One of the greatest aids in comparing fuels is a carefully-run boiler test. This may be either an efficiency test or what is known as a "service test." Efficiency tests are usually of from eight to twelve hours' duration

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and are run with as nearly a uniform load as possible, accurate records being kept of the weights of coal and water and of the other important items. These tests are generally fired by experienced men, and every precaution is taken to attain the best results. For this reason they are valuable in that they show what it is possible to do with any given fuel, but are not reliable indications of what may be expected under operating conditions. The so-called "service test" should cover a period of two days or more and consists in measuring the water and coal fed to one or more boilers which are in the hands of the regular boiler-room crew and are carrying the normal daily load. This test indicates the results that may be expected from a coal in regular daily operation, which is the real criterion of its value in a given plant. The clinkering properties and other characteristics of the fuel are then discovered.

The principal requirements then for the coal best suited to the plant are that it shall be able to produce the desired amount of steam at all times with the given equipment, that it shall satisfy the requirements as to smokelessness, absence of dust, etc., and that it shall be the most economical fuel. The most economical fuel for any plant with a given equipment is that which will produce a given output at the lowest cost, including the cost of the fuel itself, and the attendant cost of labor and maintenance.

Mention should be made here of the advantages of purchasing coal under specifications. This method is coming into wider and wider use, particularly with the Federal state and municipal governments. The advantages of buying coal under specifications such as are used by the Federal Government are that a definite standard of quality for the coal is set and a bonus or penalty is paid for variations from this standard, thus protecting the purchaser from loss due to inferior coal. If the coal deviates so far from the standard set as to be unfit for use in the plant, the purchaser may resort to the clause in the contract which allows him in such cases to reject the coal and purchase in the open market at the contractor's expense. The disadvantage of this method of purchasing fuel is that many dealers hesitate to bid by reason of their unfamiliarity with its workings.

In any event it is obvious that the benefits expected from the selection of the most suitable fuel cannot be realized unless the quality of the coal supplied is uniform and up to the original standard. The purchaser should check the shipments of coal by frequent analyses and insist that the standard of quality be maintained.

[A full page of text and an excellent series of pictures showing the progressive steps in selecting samples of coal for analysis appeared on pages 684 and 685 of *Power* for June 20, 1916.—Editor.]

Indicating the Ammonia Compressor—V*

By Robert H. Karl†

SYNOPSIS—Taking diagrams from the suction and discharge pipes. The effect of clearance is discussed, and those conditions that cause its increase during operation, namely worn pins and bearings, are considered.

It is of interest to take diagrams from the suction and discharge pipes at the time the compressor is indicated. A special fitting is used, which connects the compressor cylinder to the indicator and to the suction and discharge pipes. The advantage of this is that all diagrams may be obtained without changing the indicator around to the different locations. Fig. 23 shows one layout of the connection.

It is important that there be no lost motion in the indicator for pipe diagrams and that fine, distinct lines be traced, because of the close proximity of the lines. Study the conditions as revealed by these diagrams and compare them with the compressor-cylinder conditions. The pressure gages may be checked by the use of the indicator.

In taking suction-pipe diagrams use a 16- or 20-lb. spring or any low-pressure spring that closely corresponds to the suction pressure carried, instead of the high-pressure spring used for cylinder or discharge-pipe diagrams, as the low-pressure spring will show up variations in pressures impossible for the high-tension springs to reveal on such low pressure.

Fig. 24 shows a diagram taken with a 110-lb. spring and the suction-pipe diagram taken with a 20-lb. spring. It must be understood that pipe-pressure diagrams show the existing conditions for both ends of the stroke. When the piston is practically at rest at the end of the stroke, the pressure indicated by *A* represents the true pressure

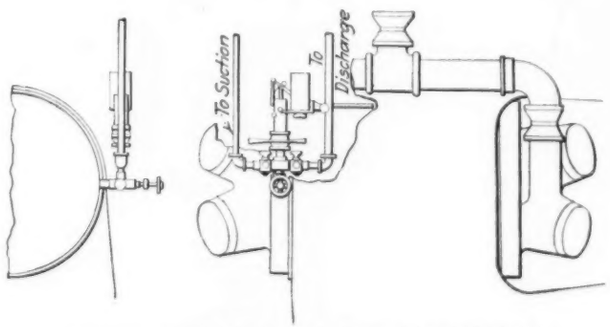


FIG. 23. SPECIAL INDICATOR CONNECTIONS

in the suction pipe. Notice the drop in pressure as the piston moves forward, which indicates that the pipe is not large enough to permit the proper flow of gas.

Fig. 25 shows a diagram from another compressor with discharge-pipe pressure diagram and also the suction-pressure diagram. The compressor and discharge-pipe diagrams were taken with an 85-lb. spring and the suction-pipe diagram with a 20-lb. spring. Observe in this case that the suction-pressure diagram shows no variation of pressure in the suction pipe when the piston moves forward from the end of the stroke. Notice also the increase

*The other articles of this series appeared in "Power" for Apr. 25, May 16, June 27 and July 25.

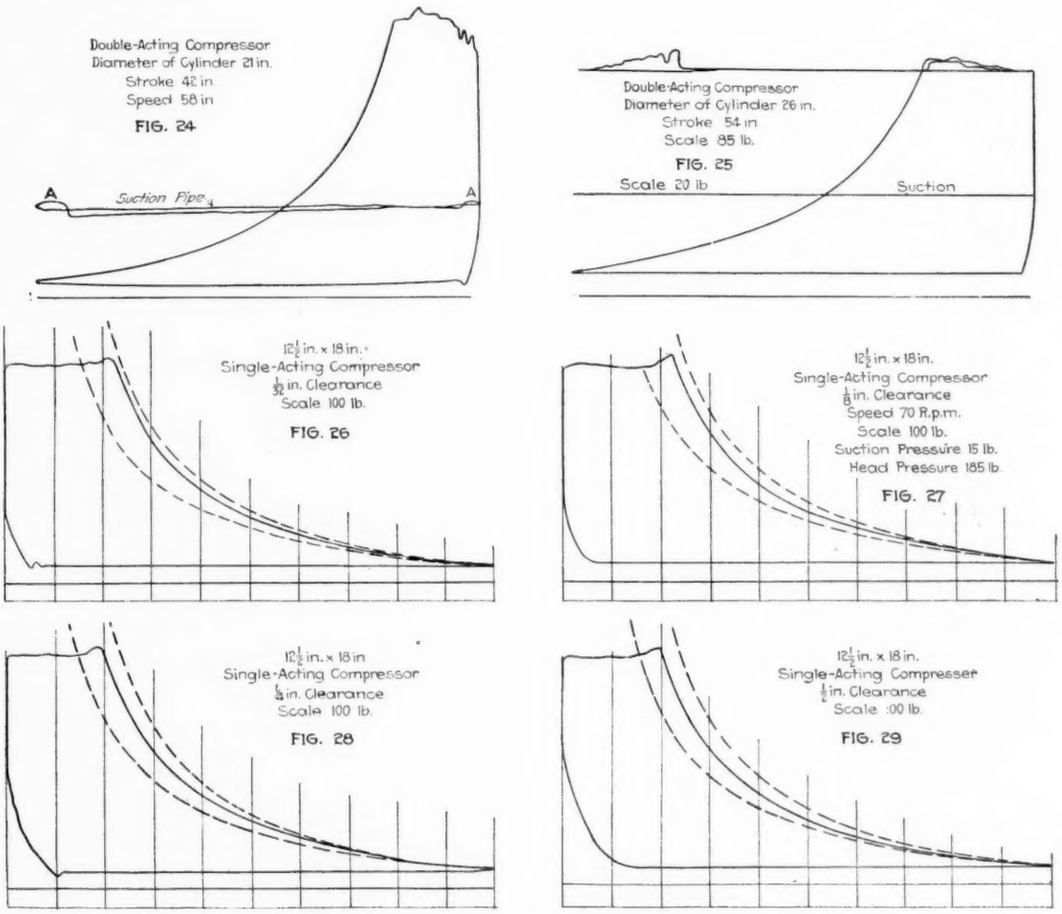
†Engineering department, Anheuser-Busch Brewing Association, St. Louis, Mo.

of the pressure on the diagram from the discharge pipe and its relation to the discharge gas from the compressor, as shown by the diagram.

It seems to be the opinion of most engineers that the reduction of clearance in the compressor to the lowest limit is of the greatest importance; but the consequence of this is much overrated. Clearance space has only a slight effect on the efficiency of a compressor, but it is detrimental to the capacity, and the greater the difference in the clearance space. These cards are reproduced by permission of the York Manufacturing Co., York, Penn.

Some interesting deductions were made from these clearance tests relative to the effect on horsepower required per ton, the effect of clearance on the capacity of compressors and the relative losses due to clearance and reexpansion of single- and double-acting machines.

Table 2 will show the effect of capacity and horsepower per ton due to clearance, based on 15.67 lb. suction pressure, 185 lb. condenser pressure and 70 revolutions per minute.



DIAGRAMS FROM COMPRESSOR CYLINDER AND PIPES

Fig. 24—A shows pressure in suction pipe. Fig. 24—A discharge pipe diagram is shown at the top.
Figs. 26 to 29—Taken to determine losses due to clearance

pressures the greater the losses. The work per unit of volume pumped is practically the same, zero clearance or not. That is, assume a compressor with zero clearance, then give it clearance; the capacity is reduced, but the amount of work done per unit of capacity, other things remaining equal, is practically unaltered.

In double-acting compressors the clearance is fixed and cannot be much altered. In single-acting compressors it can be reduced to the lowest mechanical limit, and this offers an advantage over the double-acting machine. There is generally more clearance in a compressor when in operation than is supposed, as loose bearings can produce excessive clearance, and the amount of reëxpansion which follows can best be determined by the indicator.

The diagrams, Figs. 26 to 31, are from tests taken expressly to determine the losses due to clearance, by one of the largest compressor builders in this country. Each states the type of machine from which it was taken—that is, single- or double-acting—also the linear

TABLE 2. EFFECT OF CAPACITY AND HORSEPOWER DUE TO CLEARANCE

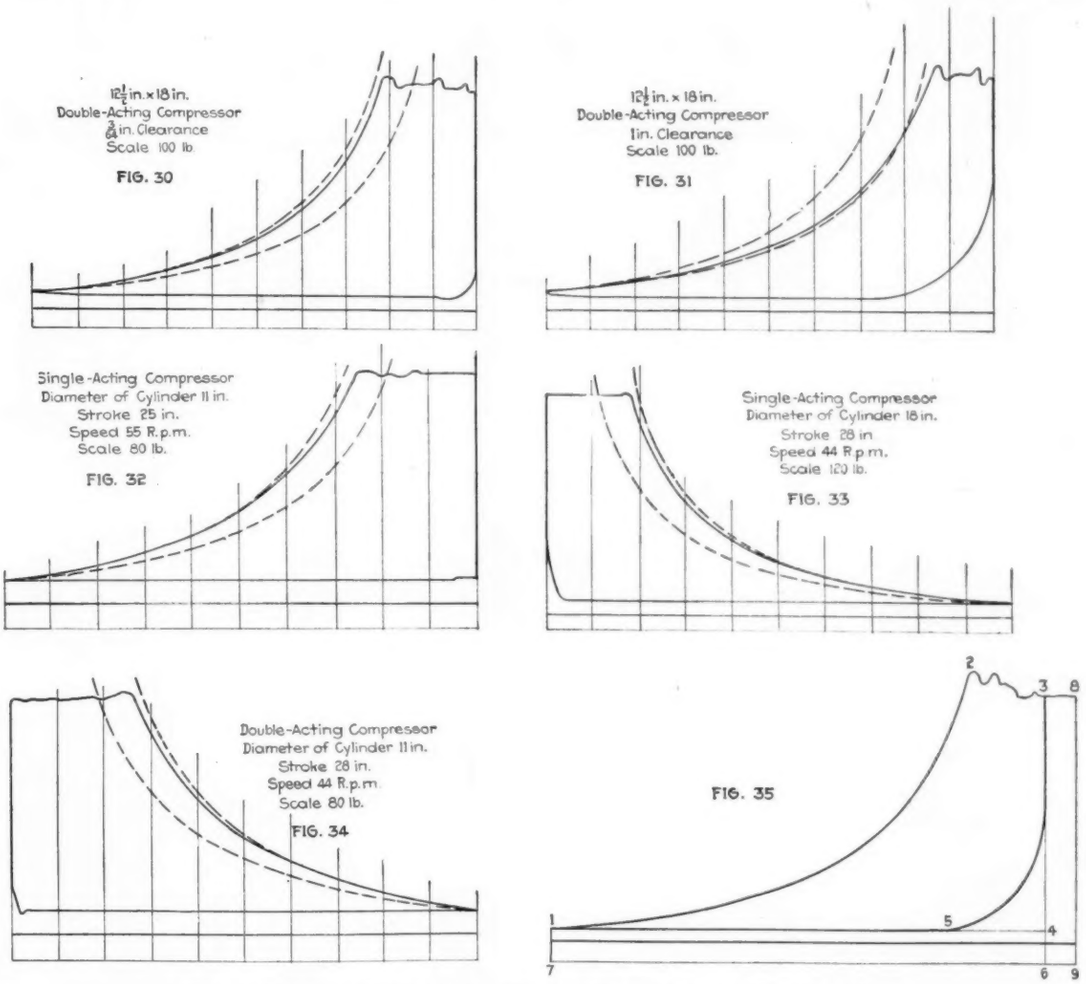
Linear Clearance, In.	Clearance Volume Per Cent. of Displacement		Single-Acting, 15.67 Lb. Suction Pressure		Double-Acting, 15.67 Lb. Suction Pressure	
	Single-Acting	Double-Acting	Tons Refg.	Compressor I.Hp.	Tons Refg.	Compressor I.Hp.
1/32	0.24	...	38.0	1.30	...	...
1/16	...	0.42	...	...	33.0	1.60
1/8	0.76	0.85	37.2	1.32	32.1	1.62
1/4	1.46	1.55	35.6	1.34	30.0	1.64
1/2	2.85	2.93	34.4	1.36	28.9	1.72
1	5.63	5.71	29.7	1.39	22.9	2.01

Figs. 32 to 34 show small clearance from both single- and double-acting compressors and are from small and large compressors. These machines have never given any trouble operating with such small clearance, and unless very carefully operated and handled, I would not advise reducing the clearance to such a point. It is much safer and better to allow a little more clearance, and it would cause no serious loss if the compressor is not hand-

ling liquid (which it ought not to), as liquid would cause a reëxpansion loss if the machine had too much linear clearance. Even with small clearance, liquid would cause reëxpansion losses, much more so than a compressor with greater linear clearance handling only dry or saturated gas; and besides, the presence of liquid in the cylinder is apt to cause damage, as well as loss in efficiency.

Referring to Fig. 35, lines 1, 2, 3, 4, 5 show the clearance diagram, line 1 to 4 represents the compressor stroke and line 3 to 8 represents the clearance volume, including linear clearance and that of the passages and of absolute temperatures before and after admission. If T_1 is the suction temperature of the gas, and T_2 the gas temperature in the cylinder at the completion of the suction stroke, the expression for volumetric efficiency must be the apparent volumetric efficiency multiplied by $\frac{T_1}{T_2}$. This loss the indicator does not show.

Due consideration must also be given the inlet passage, which may be too small for the volume, so that the gas at the completion of the suction stroke may have a lower pressure in the cylinder than in the suction pipe; on the



FIGS. 30 TO 35. TYPICAL DIAGRAMS FROM AMMONIA COMPRESSORS

Figs. 30 and 31—Taken to determine losses due to clearance. Figs. 32 to 34—Diagrams show small clearances. Fig. 35—A clearance diagram

ports. The gas is discharged at pressure p_2 along the line 2-3, and at the point 3 the piston reverses and the discharge valve closes. The volume of gas represented by the clearance space 3-8 expands along 3-5 until at 5 the suction pressure is reached and the suction valve opens. The volume drawn from the suction pipe is now 1-5 and not that of the piston displacement 1-4; the ratio of 1-5 to 1-4 is called the apparent volumetric efficiency.

The apparent volumetric efficiency becomes the real volumetric efficiency when the temperature of the gas, after it has entered the cylinder, is equal to the temperature of the outside gas. During admission to the cylinder the temperature of the gas is raised by coming in contact with hot surfaces, which superheat the suction gas; thus the weight of gas admitted will be decreased in the ratio

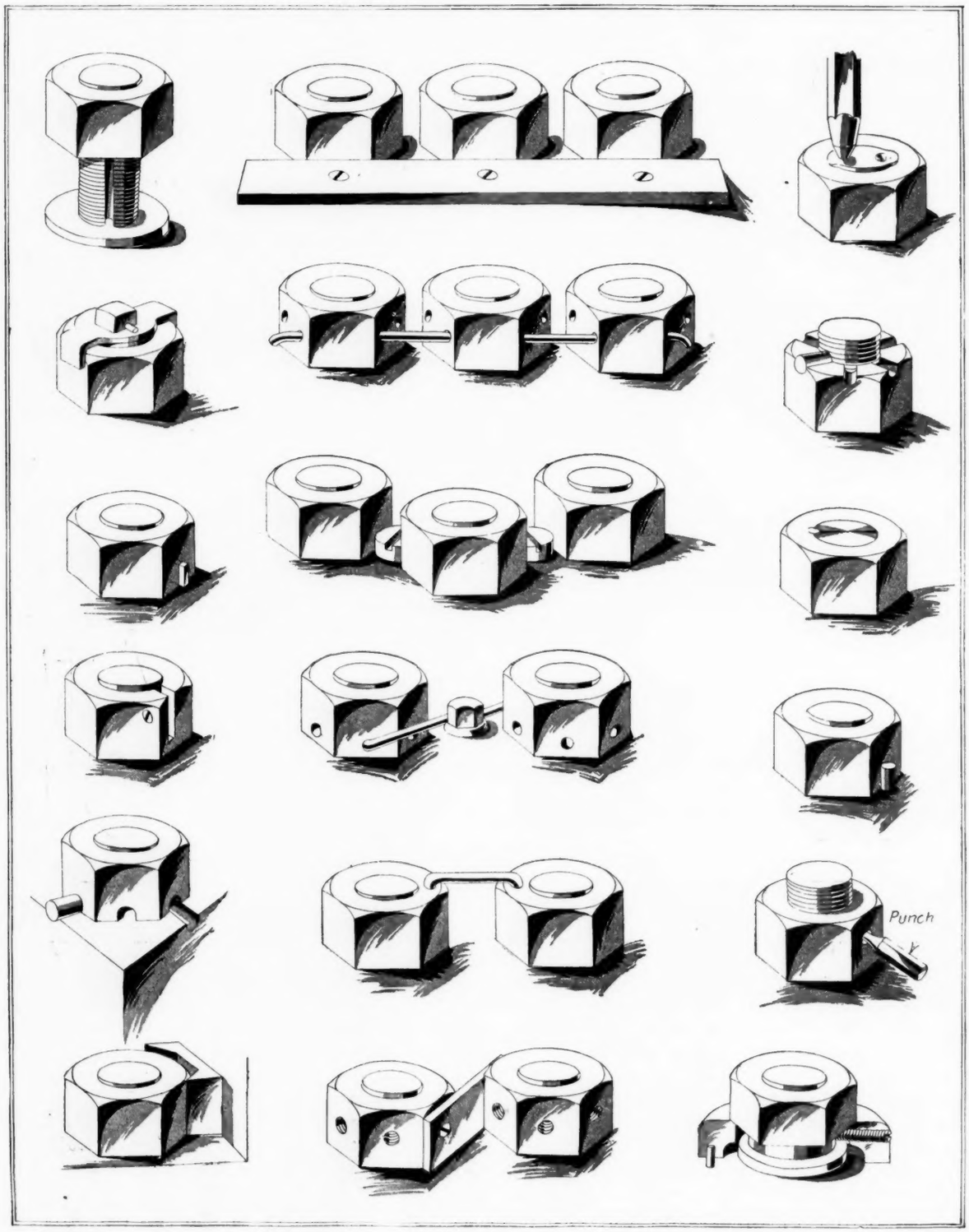
other hand, it is also possible, by means of large ports and suction pipes, to have the pressure at completion of the suction stroke greater than that in the suction pipe, because of inertia of the gas in the long pipes. The piston reversal suddenly checks the gas flow and may cause the pressure to rise in the cylinder.

[*The next article describes how to apply the indicator and what precautions must be taken to avoid certain troubles and inaccuracies.—Editor.*]

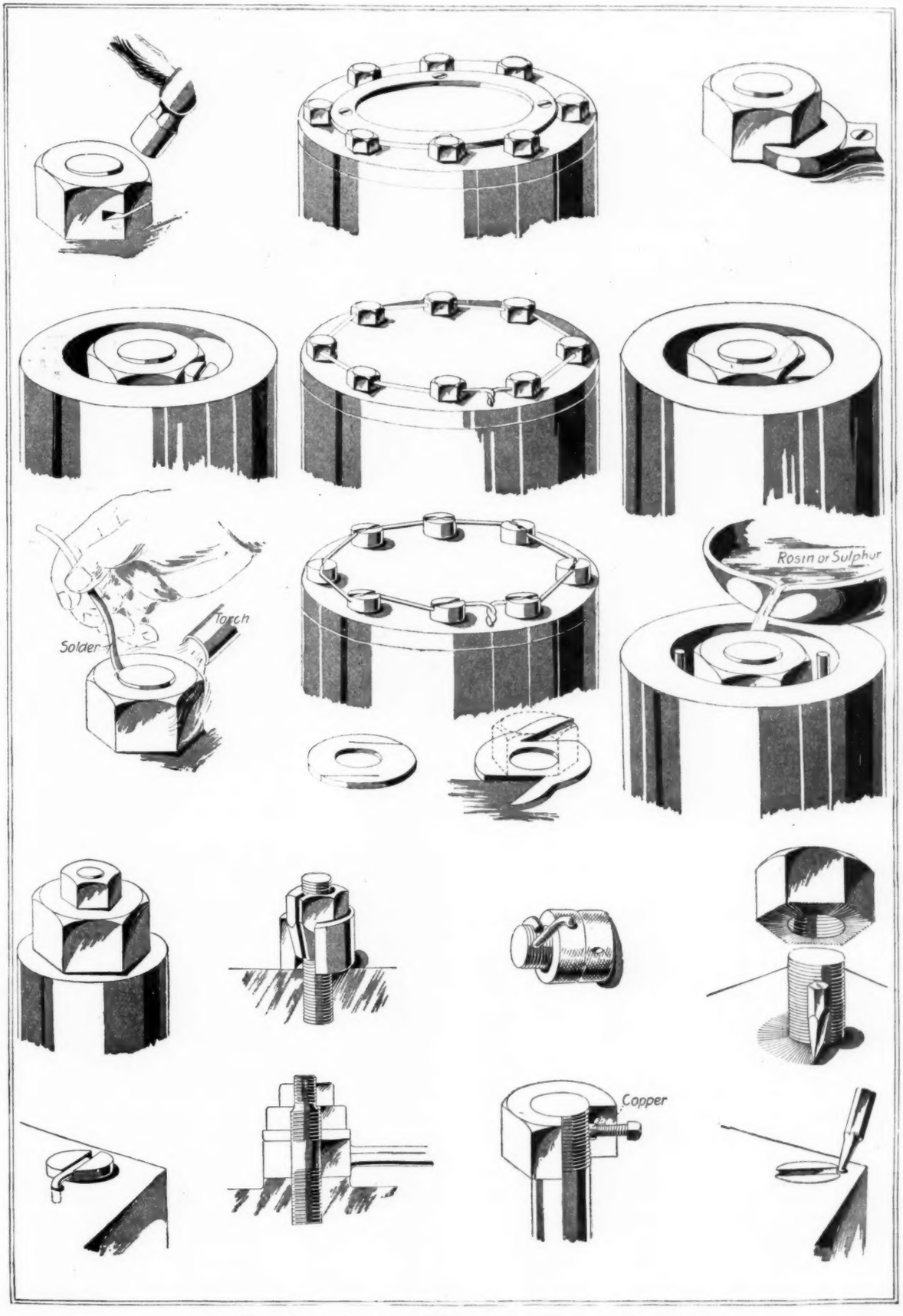
A Mixture for Preventing Scale in boilers, consisting of graphite and caustic soda in the proportion of 50 oz. to 30 lb., has been found effective, it is said, by the chief engineer of a private plant operating two 260-hp. B. & W. boilers. The boilers are treated alternately, the mixture being fed gradually to one boiler, and during that time it is not blown down. The other unit, however, is blown down every morning.

From a Small-Shop Notebook

By John H. Van Deventer



A NUT THAT WORKS LOOSE HAS BUT LITTLE VALUE



THESE PAGES SHOW A NUMBER OF WAYS OF LOCKING NUTS

From "American Machinist"

Direct-Current Wiring Tables

By Cecil P. Poole

SYNOPSIS—Five tables are given, with an explanation of how to use them, for finding the sizes of conductors for light and power circuits.

The accompanying tables will be found convenient and free from the objection that applies to almost all other forms, namely, that considerable calculation and judgment are required to use them. Anyone that can add numbers can use these tables; no multiplication, division or exercise of electrical judgment is necessary.

TABLE 1. PROPERTIES OF COPPER WIRES

Wire No. B. & S. Gage	Circ. Mils	Maximum Current Allowed Rubber Insul.	Maximum Current Allowed Other Insul.	Volts Drop per Foot of Distance for Two-Wire Circuit: Carrying One Ampere	Carrying Maximum Current Rubber	Carrying Maximum Current Other Insulations	Carrying 80 Per Cent. of Maximum Current Rubber	Carrying 80 Per Cent. of Maximum Current Other Insulation
0	105,500	125	200	0.000201	0.0251	0.0402	0.0201	0.0322
1	83,690	100	150	0.000252	0.0252	0.0378	0.0202	0.0302
2	66370	90	125	0.000358	0.0322	0.0448	0.0258	0.0358
3	52,630	80	100	0.000403	0.0322	0.0403	0.0258	0.0322
4	41,740	70	90	0.000506	0.0354	0.0455	0.0284	0.0365
5	33,100	55	80	0.000638	0.0351	0.0510	0.0281	0.0409
6	26,250	50	70	0.000805	0.0403	0.0564	0.0322	0.0451
8	16,510	35	50	0.00128	0.0448	0.064	0.0359	0.0512
10	10,385	25	30	0.00204	0.051	0.0612	0.0408	0.049
12	6,530	20	25	0.00324	0.0648	0.082	0.0519	0.0648
14	4,107	15	20	0.00515	0.0773	0.103	0.0618	0.0824
16	2,583	6	10	0.0082	0.0492	0.082	0.0394	0.0656

Instead of giving the ampere-feet and drop for the different wire sizes, these tables deal with the current and distance separately, and all that the user needs to do in the way of exercising judgment is to know roughly how much drop is allowable. In order to eliminate, as far as possible, the need for judgment on this point, the following simple rule for lamp circuits is given:

TABLE 2-A. CURRENT, DISTANCE AND DROP

The Numbers in the Body of the Table Are Amperes

	0.5 Volt Drop				0.75 Volt Drop				1 Volt Drop			
Feet	No. 8	No. 10	No. 12	No. 14	No. 8	No. 10	No. 12	No. 14	No. 8	No. 10	No. 12	No. 14
10	39.0	24.5	15.4	9.7	....	....	23.1	14.6	....	....	....	....
13	30.0	18.8	11.9	7.5	45.1	28.3	17.8	11.2	....	....	23.7	14.9
16	24.4	15.3	9.6	6.1	36.6	23.0	14.5	9.1	48.8	30.6	19.3	12.1
20	19.5	12.3	7.7	4.9	29.3	18.4	11.6	7.3	39.0	24.5	15.4	9.7
25	15.6	9.8	6.2	3.9	23.4	14.7	9.2	5.8	31.2	19.6	12.3	7.8
30	13.0	8.2	5.1	3.2	19.5	12.3	7.7	4.9	26.0	16.3	10.3	6.5
35	11.1	7.0	4.4	2.8	16.7	10.5	6.6	4.2	22.3	14.0	8.8	5.5
40	9.8	6.1	3.8	2.4	14.6	9.2	5.8	3.6	19.5	12.2	7.7	4.8
45	8.7	5.4	3.4	2.15	13.0	8.2	5.1	3.2	17.3	10.9	6.9	4.3
50	7.8	4.9	3.1	1.95	11.7	7.3	4.6	2.9	15.6	9.8	6.2	3.9
55	7.1	4.4	2.8	1.75	10.6	6.7	4.2	2.6	14.2	8.9	5.6	3.5
60	6.5	4.1	2.6	1.62	9.7	6.1	3.9	2.4	13.0	8.2	5.1	3.2
65	6.0	3.8	2.4	1.5	9.0	5.6	3.5	2.2	12.0	7.5	4.7	3.0
70	5.6	3.5	2.2	1.38	8.3	5.2	3.3	2.1	11.1	7.0	4.4	2.77
75	5.2	3.2	2.0	1.3	7.8	4.9	3.1	1.94	10.4	6.5	4.1	2.6
80	4.9	3.1	1.93	1.21	7.3	4.6	2.9	1.82	9.7	6.1	3.8	2.42
85	4.6	2.9	1.81	1.14	6.9	4.3	2.7	1.71	9.2	5.8	3.6	2.29
90	4.3	2.7	1.72	1.08	6.5	4.1	2.6	1.62	8.7	5.4	3.4	2.15
95	4.1	2.6	1.62	1.02	6.1	3.9	2.4	1.53	8.2	5.2	3.2	2.04
100	3.9	2.4	1.54	0.97	5.8	3.7	2.3	1.45	7.8	4.9	3.1	1.94

For feeders the drop may be from 1.33 to 2 volts; for mains it should be as small as practicable without entailing the use of unduly large wires, so it will be safe to assume 0.75 volt or less for mains that are served by feeders having 1.5 to 2 volts drop; when the drop in the feeder is less than 1.5 volts, the drop in the main may be 1 volt, but a little less is preferable.

No rule is necessary for motor circuits; Table 4 covers all cases that are likely to come within the practice of men who are not skilled in laying out complex circuits.

Table 1 is the foundation of all wiring computations. It shows the current that the insurance rules allow for interior wires; the drop in volts per foot of distance for a two-wire direct-current circuit carrying one ampere (column 5), carrying the maximum allowable current (columns 6 and 7) and carrying 80 per cent. of the maximum allowable current (columns 8 and 9). The use of the last two columns is to determine the drop with the greatest motor current that the wire is allowed to carry. The fifth column is in accord with the latest figures issued by the Government Bureau of Standards as applying to annealed copper wires such as are commonly used for electrical circuits.

TABLE 2-B. CURRENT, DISTANCE AND DROP

The Numbers in the Body of the Table are Amperes

	1.33 Volts Drop				1.66 Volts Drop				2 Volts Drop			
Feet	No. 8	No. 10	No. 12	No. 14	No. 8	No. 10	No. 12	No. 14	No. 8	No. 10	No. 12	No. 14
17	....	....	24.3	15.3	....	....	....	19.1	....	....	....	....
20	....	....	20.6	12.9	....	....	25.7	16.2	....	....	....	19.9
25	41.6	26.1	16.5	10.3	....	....	20.6	12.9	....	....	24.7	15.9
30	34.7	21.8	13.7	8.6	43.4	27.2	17.1	10.8	....	....	20.6	13.3
35	29.7	18.7	11.7	7.4	37.2	23.3	14.7	9.2	44.6	28.0	17.6	11.4
40	26.0	16.3	10.3	6.5	32.5	20.4	12.8	8.1	39.0	24.5	15.4	10.0
45	23.1	14.5	9.1	5.7	28.9	18.1	11.4	7.2	34.7	21.8	13.7	8.8
50	20.8	13.0	8.2	5.1	26.0	16.3	10.3	6.4	31.2	19.6	12.3	7.9
55	18.9	11.9	7.5	4.7	23.6	14.8	9.3	5.9	28.4	17.8	11.2	7.2
60	17.3	10.9	6.8	4.3	21.7	13.6	8.5	5.4	26.0	16.3	10.3	6.6
65	16.0	10.0	6.3	4.0	20.0	12.5	7.9	5.0	24.0	15.1	9.5	6.1
70	14.9	9.3	5.9	3.7	18.6	11.7	7.3	4.6	22.3	14.0	8.8	5.7
75	13.9	8.7	5.5	3.4	17.3	10.9	6.8	4.3	20.8	13.1	8.2	5.3
80	13.0	8.1	5.1	3.2	16.2	10.2	6.4	4.0	19.5	12.2	7.7	5.0
85	12.2	7.7	4.8	3.0	15.3	9.6	6.0	3.8	18.4	11.5	7.2	4.7
90	11.5	7.2	4.5	2.9	14.4	9.1	5.7	3.6	17.3	10.9	6.8	4.4
95	10.9	6.9	4.3	2.7	13.7	8.6	5.4	3.4	16.4	10.3	6.5	4.3
100	10.4	6.5	4.1	2.6	13.0	8.2	5.1	3.2	15.6	9.8	6.2	4.0

Tables 2-A and 2-B show the strength of a direct current that may be carried different distances by each of four wire sizes with different drops in voltage, ranging from 0.5 volt to 2 volts. These tables are intended for application to lamp circuits in conjunction with Table 3, which is self-explanatory.

Table 4 applies only to direct-current motor circuits and covers all ordinary problems in which a motor is supplied by its own circuit individually. For cases in which several motors are fed from a single main, as in large motor-driven industrial plants, the wiring must be laid out by one skilled in such matters and the sizes calculated from fundamental data as given in Table 1.

TABLE 3. CURRENT REQUIRED BY 110-VOLT INCANDESCENT LAMPS

Number	20 Watts	25 Watts	40 Watts	60 Watts	100 Watts
1	0.18	0.23	0.36	0.55	0.91
2	0.36	0.46	0.73	1.09	1.82
3	0.55	0.68	1.09	1.64	2.73
4	0.73	0.91	1.46	2.18	3.64
5	0.91	1.14	1.82	2.73	4.55
6	1.09	1.36	2.18	3.28	5.46
7	1.27	1.59	2.55	3.82	6.37
8	1.46	1.82	2.91	4.36	7.27
9	1.64	2.05	3.27	4.91	8.18
10	1.82	2.27	3.64	5.46	9.09
11	2.00	2.50	4.00	6.00	10.00
12	2.18	2.73	4.36	6.55	10.92
13	2.36	2.96	4.73	7.09	11.82
14	2.55	3.18	5.09	7.64	12.73
15	2.73	3.41	5.46	8.18	13.64
16	2.91	3.64	5.82	8.73	....
17	3.09	3.86	6.18	9.27	....
18	3.27	4.09	6.55	9.82	....
19	3.46	4.32	6.91	10.36	....
20	3.64	4.55	7.27	10.91	....
21	3.82	4.77	7.64	11.45	....
22	4.00	5.00	8.00	12.00	....
23	4.18	5.23	8.36	12.55	....
24	4.36	5.45	8.73	13.09	....
25	4.55	5.68	9.09	13.64	....
26	4.73	5.91	9.45	14.18	....
27	4.91	6.14	9.82	14.73	....
28	5.09	6.36	10.18	15.27	....
29	5.27	6.59	10.55	15.82	....
30	5.46	6.82	10.91	16.36	....

A few examples will serve to illustrate the simplicity of application of the tables. Suppose a light circuit is to be run 20 ft. from a panel board or other source of distribution, and it is to serve 18 lamps of 25 watts each, 4 of 40 watts and one of 100 watts; what size of wire should be used?

From Table 3 it will be evident that

18	25-watt lamps require	4.09 amperes
4	40-watt lamps require	1.46 amperes
1	100-watt lamp requires	0.91 ampere
Total		6.46 amperes

Table 2-A shows that No. 12 wire will carry 7.7 amp. 20 ft. with a drop of 0.5 volt and that No. 14 will carry 7.3 amp. 20 ft. with a drop of 0.75 volt; therefore, if No. 12 be used, the drop will be less than 0.5 volt and if No. 14 be used, the drop will be considerably less than 0.75 volt, with all lamps burning. No. 14 would naturally be the size to use, because it will cost much less than No. 12 and the drop will be small enough to prevent a serious drop in candlepower.

Again, suppose a circuit is to be run 35 ft. to a cluster of six 40-watt lamps, and outlets are to be provided for two 100-watt lamps near the cluster. From Table 3,

TABLE 4. 230-VOLT MOTOR CIRCUITS

			Distance Motor Can Be Fed with Drop of					
Hp.	Current Required	Wire Size	2 Volts	2.5 Volts	3 Volts	3.5 Volts	4 Volts	5 Volts
0.5	2.25	14	173	216	259	302	345	430
1	4.1	14	94	118	142	165	189	236
1.5	6.1	14	63	80	95	111	127	159
2	8.1	14	48	60	72	84	96	120
3	11.8	12*	52	65	78	91	104	130
4	15.5	10*	63	79	95	111	126	158
5	19.2	10	51	64	76	89	102	127
7.5	28.8	8	54	67	81	94	108	135
10	38.0	6	65	82	98	114	130	163
12.5	46	5	68	85	102	119	136	170
15	56	4	70	88	106	123	141	176
20	74	2	75	94	113	132	151	188

* The next smaller size would "squeeze by" under the insurance rules, but the size here given is preferable because of the margin for slightly lower efficiency, or abnormal starting current, etc.

the current will be $2.18 + 1.82 = 4$ amp.; from Table 2-A it is evident that No. 14 wire will carry the load with 0.75 volt drop, but if the lamps are all to be burned at the same time, it will be preferable to use No. 12 wire and have a drop of 0.5 volt or a trifle under.

Suppose a 40-ft. feeder is to be run to a panel board from which are taken circuits to thirty-two 25-watt lamps, nineteen 40-watt lamps, eight 60-watt lamps and two 100-watt lamps. From Table 3, the total current will be $7.28 + 6.91 + 4.36 + 1.82 = 20.37$ amp.; and Table 2-B shows that No. 10 wire will carry the load with a drop of 1.66 volts.

Table 4 scarcely requires any explanation. The motor currents there given are those required by General Electric standard medium-speed 230-volt motors, and they do not differ radically from the currents taken by other reliable makes of motor. It is a safe rule to keep the drop in a motor circuit as low as practicable, and it should never exceed 5 volts. It will be evident from an inspection of the 2-volt column of the table that a drop of this magnitude, or even less, is practicable under most circumstances; the shortest distance to which one is limited at that drop is 48 ft., for a 2-hp. motor fed by No. 14 wire. All the wire sizes specified in the table except those marked by asterisks are the smallest that the insurance rules allow for a current 25 per cent. in excess of the motor current.

In Placing Rubber Packing for joints it should be coated with either graphite or chalk to prevent adhering to the metal when the joint is to be broken.

Water Power Could Not Displace Steam*

By Edgar White

The town of Macon, Mo., is built over a bed of bituminous coal, which ranges from 22 to 26 in. in thickness. Prospect holes sunk all around the town have located the bed, and one colliery is now electrically mining the product. Any man in the city could sink a shaft in his back yard, from 80 to 100 ft. deep and be independent of the coal dealer.

When the Keokuk Power Co. began reaching out for business a subcontracting firm sent representatives to Macon with an offer to furnish the city and private consumers with electrical energy at 3½c. per kw.-hr. Neighboring towns were asked to come in on the proposition.

The section which the water-power company proposed to invade was about 130 mi. from the dam. Coal was, as stated, in the back yards of the people.

C. F. Thudium, superintendent of the municipal power plant at Macon, got out his pencil and did some figuring. He found that with coal-produced power he could undersell his big competitor over on the Mississippi River. With a plant of 400 hp., composed of two engines, direct-connected to generators, and with the pithead of the mine within arm's reach of the power house, he discovered that, based on water-power rates, the coal-produced energy was saving the city $400 a month.

He then went after the outside business in the same way that the hydro-electric people were doing, and closed contracts with the neighboring towns of Bevier and Callao for the transmission of electrical power, and is now figuring with some of the large coal towns in the Bevier district for the same sort of service. After a year's operation as a central power station, the Macon municipal plant has been able to show an annual profit of $5,000 above operating expenses.

Not long ago there was a vote taken to issue $30,000 worth of bonds to extend the water mains, put in a filter and improve the reservoir. The guarantee was given by the administration that the earnings of the power plant would take care of the entire debt, and the proposition carried almost unanimously. Every payment has been met promptly out of the fund designated.

The plant gets coal in the bin at $1.39 a ton and before long may be securing it even cheaper, as plans are now under way to utilize the slack piles or dumps that grew up under the old method of mining coal.

The municipal power house at Macon is a small brick building down in a hollow, that would not attract much more attention than a miner's shanty except for two tall stacks. And yet this plant has solved the big question of keeping up municipal improvements and steadily replenishing the treasury of a town of approximately 6,000 inhabitants.

Steam Discharges Into the Atmosphere—The pressure of the atmosphere being not more than 58 per cent. of the initial absolute steam pressure at a velocity of efflux at constant density or, supposing the initial density to be maintained, at a velocity found by the formula $V = 3{,}5953\sqrt{h}$; where V = velocity of outflow in feet per minute, h = height in feet of a column of steam of the given absolute initial pressure the weight of which is equal to the pressure on the unit of base.

*From "Coal Age."

Efficiency in the Boiler Room

By Joseph Harrington*

SYNOPSIS—The ratio of the quantity of heat actually utilized to the quantity theoretically available is the true measure of boiler and furnace performance and is the only basis on which results can be scientifically analyzed. The present method of comparing conditions with perfection fails of exactness. In efficient operation personal interest is essential and recording instruments are important. The author presents a sample daily report sheet and his follow-up system of plotting the data.

Boiler efficiency is a composite result, and its analysis requires a separation of its component parts.

In a simple chemical reaction involving but two elements, a completion of the action would leave no unfinished work and would represent 100-per cent. efficiency. But suppose, through some unfavorable condition of temperature, the action ceased when only half of the chemicals were used. The other 50 per cent. of unaltered substance would be wasted, and the process would be classed as 50-per cent. efficient. This basis of comparing actual conditions with perfection is absolute efficiency.

A perfect furnace would completely burn all the combustible in the coal fired with just the theoretical quantity of air. With no losses due to combustible in the ash, CO in the furnace gases, or excess air, the furnace efficiency would be 100 per cent. A perfect boiler would cool the gases to the temperature corresponding to the pressure and would allow no infiltration of air or radiation of heat. The boiler efficiency would then be 100 per cent. A perfect boiler and a perfect furnace would not, however, give 100-per cent. combined or absolute efficiency, because nature imposes certain restrictions upon the process of burning coal for the generation of steam.

First, coal is not a perfect fuel. Even with a perfect furnace and boiler the moisture and burned hydrogen in the coal will go up the chimney as superheated steam at the temperature to which a perfect boiler could cool the gases, but this temperature is higher than that of the atmosphere and a definite, necessary loss occurs.

Secondly, the gases must escape at a temperature at least equal to the steam temperature, which is of course always higher than the surrounding air. The theoretical quantity of dry gases also carries away heat that even a perfect boiler could not absorb.

The magnitude of these necessary losses depends upon the amount of moisture and hydrogen in the fuel, the boiler pressure and the temperature of the air in the boiler room; and until they are known, and unless all these conditions are identical or a proper allowance for their effect made, a test cannot be scientifically analyzed or two tests compared. For instance, a test at 78-per cent. combined efficiency may be a better performance of both boiler and furnace than another at 80-per cent. under different conditions, because the necessary losses might be more than enough to account for this difference. After deducting the necessary losses per pound of coal as fired from the heat contained in the coal as fired, there remains a quantity of heat all of which a perfect boiler and furnace could utilize. The ratio of the quantity of heat theoretically available to that contained in a pound of fuel as fired is the ideal efficiency. The ratio of the amount of heat actually utilized to the quantity theoretically available is the true measure of the boiler and furnace performance and is the only basis on which results can be scientifically analyzed. This ratio may be termed the actual efficiency.

Modern procedure takes no notice of all this, but assumes to compare two dissimilar things on the basis of absolute perfection, when as a practical fact the fundamental laws of physics may cause the possibilities in the two cases to be widely divergent. To illustrate this more forcibly, consider a heating boiler operating at 5 lb. gage and a locomotive at 200 lb. The temperature of the steam in the first case is 228 deg. F., while in the second it is 388 deg. F.

Actual Efficiency of Boilers

One of the laws of thermodynamics being that there can be no transfer of heat except from a body of higher temperature to one of lower, the escaping gases in the two cases must be at least 160 deg. apart. Therefore a larger portion of the total heat in each pound of coal burned in the locomotive escapes to the stack than of that burned under the heating boiler. In this case then, it would be unfair to compare the efficiency of the two boilers on the absolute basis because the locomotive could not possibly equal the heating boiler by 3 per cent.

Now suppose the maximum possible efficiency of the locomotive boiler was 85 per cent., while that of the heating boiler was 90 per cent. Operation of the two discloses that the locomotive develops an efficiency of 82 per cent. and the heating boiler an efficiency of 84 per cent. on the absolute basis. But the locomotive was developing $^{82}/_{85}$ or 96.5 per cent., of what it could possibly do, while the other boiler was doing $^{84}/_{90}$, or 93.3 per cent. of the possible maximum. This illustrates more clearly the expression actual efficiency and shows that the locomotive at 82-per cent. absolute efficiency is giving a better performance than the heating boiler at 84-per cent.

This is not an extreme case, and when the varying and considerable influence of moisture and available hydrogen is taken into account, it shows why we should be careful not to make hasty comparisons between units even as much as 5 per cent. apart in absolute efficiency.

Engineering procedure is unquestionably lax in this respect, but with the aggressive campaign for efficiencies that is now on and with the development of scientific stoking, it becomes increasingly important that accurate bases of comparison be established.

Let us turn to the problem of maintaining high boiler-room efficiency. Here we encounter the human element and reach the subject of operating efficiency, which may be defined as the measure of one's ability to maintain given physical conditions. It is an art.

Operating efficiency also is divisible by two—the records and the incentive. I shall not enter into any discussion of bonus systems, as they have been well considered by

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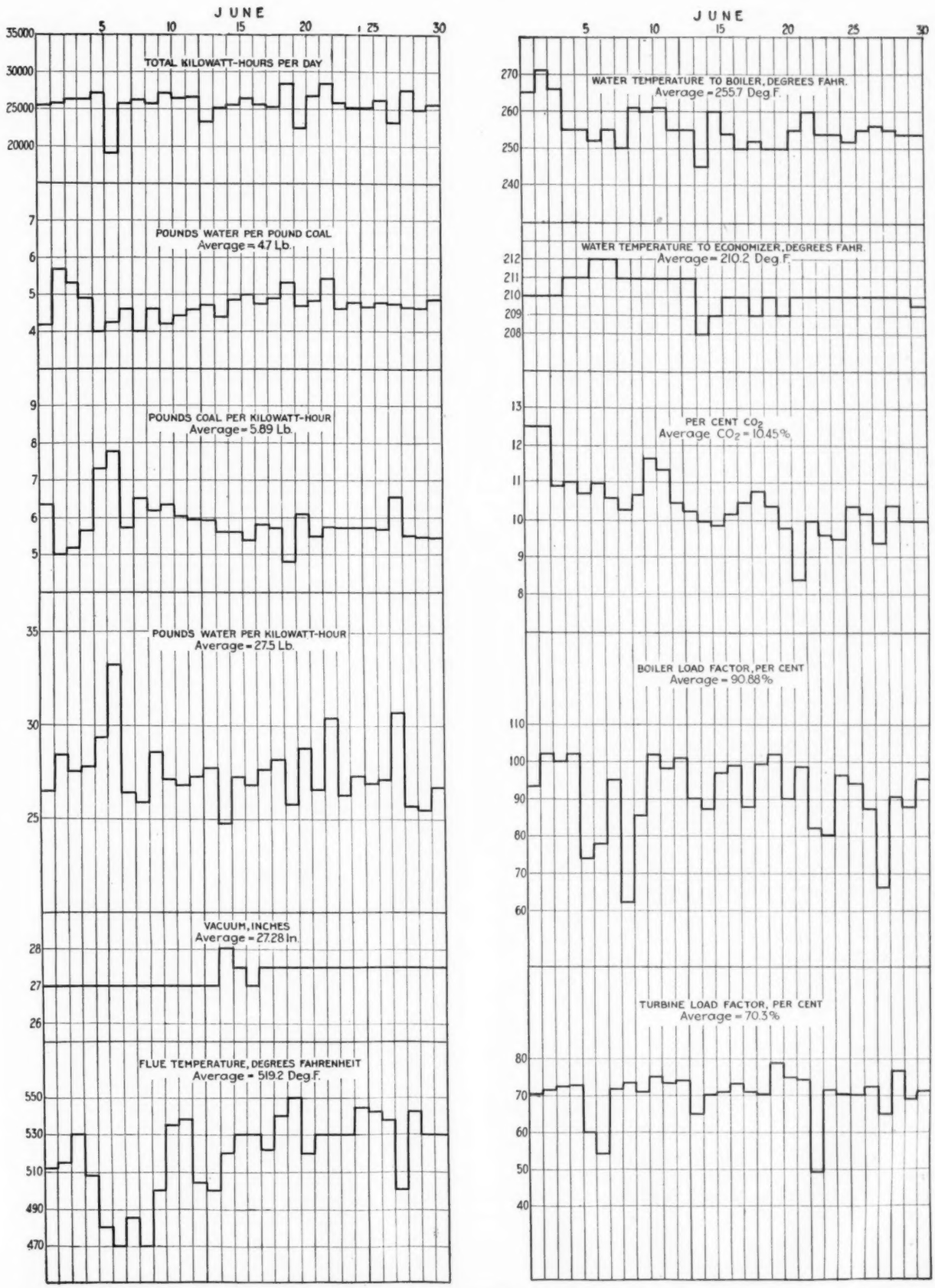


FIG. 1. GRAPHIC RECORD OF MONTH'S OPERATION OF WATERLOO (IOWA) PLANT

others. Where pride in one's work and efficiency for its own sake are not sufficient, I believe in a well-considered bonus system as an incentive to sustained effort. Personal interest is an essential in the efficient operation of a steam boiler. It should not, however, be burdened with the necessity of overcoming instrumental deficiencies or asked to perform the impossible. On the contrary, the operator should be aided in every way possible, and the service brought as near as practicable to a state of mathematical precision. Some work I have attempted along these lines will be outlined.

In the first place recording instruments are a necessity. Draft in a boiler is constantly fluctuating and will vary greatly with the changes in the character of the fuel, thickness of the fire, temperature of the stack gases, etc. A single reading or set of readings is not sufficient evidence upon which to base a judgment. A true average, even, may lead to the most erroneous conclusions. Consider the draft in the furnace of a chain-grate installation. Excellent fuel-bed conditions produce a furnace draft of, say, 0.20 in. An ordinary indicating draft gage is used, and hourly readings are taken and recorded. For twelve hours the boiler is operated with a long, tight fire and a draft of 0.30 in., and for the other 12 hr., with a short ragged fire and a draft of 0.10 in. The average would be 0.20 in., and the daily log going to the chief engineer's desk would bear this figure. The log would give no clue to the cause of the high coal consumption for that day, and would be useless or worse. The recorder chart would have shown the trouble instantly and lastingly and would have been available for reference.

Instruments for the Boiler Room

The first thing, then, is a recording draft gage serving the furnace and the boiler uptake, and if a forced-blast stoker is used another gage must be connected to the windbox. With these is measured the fuel bed and boiler resistance and the draft at both the furnace and the damper. Not the slightest change can occur without its showing on the chart. The significance of drafts has been so fully presented in *Power* that no attempt will be made to discuss it here. Suffice it to say that a condition of efficient combustion having once been established and these drafts noted, a return to the same set of draft conditions will result in the same condition of efficiency. [Provided the character of the fuel does not change.—Editor.]

In addition to the draft recorders, a recording flue-temperature thermometer should be attached for keeping a check on the condition of the heating surface. Inasmuch as flue temperature necessarily varies with capacity, judgment of the proper temperature must be based on a knowledge of the rate of steaming. A recording steam-flow meter will of course show this in the most direct way and will indicate the number and extent of the many fluctuations in the steam output. All of this information is interesting and much of it important, but again the draft-gage combination will give the indications of capacity with sufficient clearness to show whether the gas temperature is right or not.

Variations in the draft loss in any given boiler are in direct ratio to the volume of gases passing through the setting. When the weight of air per pound of coal is constant, the draft loss in the boiler becomes a measure of the amount of coal burned or the capacity of the boiler at that moment.

Having established the conditions of efficiency and arranged for the averaging of all charts, it only remains to use the information profitably. A daily report is made out by the station engineer as shown herewith. This happens to be for a street-railway power house, but may be modified to suit any particular service.

A large sheet of specially ruled cross-section paper is prepared for the development of a series of curves with the days of the month as abscissas and the daily data as ordinates. Fig. 1 shows one month's record at the Waterloo, Cedar Falls & Northern Railway Co.'s power house at Waterloo, Iowa. It is most interesting to analyze the causes of changes in coal per kilowatt-hour. In the absence of frequent coal analyses this ratio becomes the criterion of efficiency. Coal and ash samples are taken daily and an analysis of the accumulated samples is made at the end of the month. An idea of the heat-unit consumption per kilowatt-hour can thus be obtained and with a uniform coal supply this is fairly satisfactory. With a varying coal, analyses should be made oftener. With electric current the sole output, the ratio of heat units to kilowatt-hours is the direct index of efficiency, but with a mixed output, such as obtains in a central heating and electric-light plant, the heat units per 1,000 lb. of steam from and at 212 deg. F. is the ratio necessary to determine. The efficiency of the electrical-generating department has to be determined separately, by measuring the steam to the turbine room with flow meters, and calculating the pounds of steam or heat units per kilowatt-hour.

In the case illustrated, however, the cause of a rise in coal consumption can be located in either the boiler or turbine room. In the latter case the water rate shows the fact, and the turbine load factor or the vacuum indicates the cause. In the former case the boiler conditions are susceptible of analysis, as previously shown. Whether the loss is due to a dirty boiler, broken baffle, leaky fire, combustible in the ashpit, too many boilers in service or overloading can be shown with almost mathematical precision. Efficiency in power-plant operation is within the reach of those who do not have a special engineering department.

It is of course necessary that the recording draft gages be calibrated with a gas-analysis instrument so that a given draft loss may be known as corresponding to a certain CO_2. Every boiler installation is a problem by itself and will have its own series of draft, temperature and CO_2 readings corresponding to best efficiency. Once determined, however, these relations remain practically constant. The small-plant owner can have the instruments properly applied and written instructions prepared, so that thereafter it is a matter of watching the daily reports and charts and insisting on the maintenance of proper conditions.

Fig. 2 shows the effect of an aggressive campaign for reduction in coal cost. The old plant (previous to October, 1913) was a stoker-fired water-tube boiler plant and no worse than dozens I have seen that are still regarded with complacence or indifference by their owners. The writer designed the new settings and has been interested in the results. The last couple of months have been disturbed by the installation of new equipment to double the capacity of both boiler and turbine rooms, and this is reflected in the increased coal consumption. Performance in this plant will eventually come close to 4½ lb. of coal per kilowatt-hour.

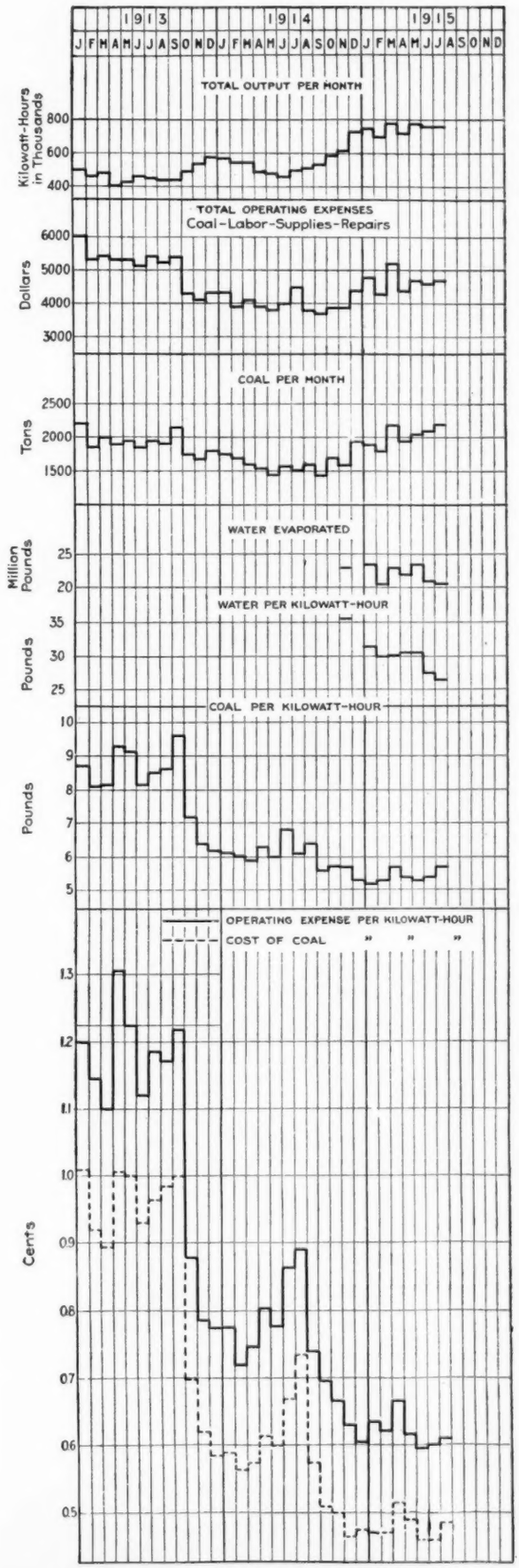


FIG. 2. EFFECT OF CAMPAIGN TO CUT COAL COST

The coal used is unwashed Iowa screenings having the following analysis for the month of June:

Moisure as received, per cent	8.9
Volatile matter, per cent	30.4
Fixed carbon, per cent	33.5
Ash, per cent	27.2
B.t.u. per lb. as received	8,463
B.t.u. per lb., dry	9,290
Ash Analysis Average for the Month:	
Combustible matter, per cent	19.8

It will be interesting to follow on the curves a typical day showing the method of analyzing the information contained. Starting from the coal per kilowatt-hour, Fig. 1 shows for June 27 a marked increase in the coal per kilowatt-hour. This at once draws attention and requires analysis. Dividing the analysis into turbine room and boiler room, we look first for the cause in the former.

DAILY REPORT

June 22, 1915.

W. C. F. & N. Ry. Co., T. E. Rust, Chief Engineer — Joseph Harrington, Consulting Engineer

Boiler in service, No.	6	7	8
Total hours	24	24	24
Turbine in service, No.	1	2	3
Total hours	24	14½	—
Turbine load factor		49.4	
Boiler load factor		82.5	
Total kw.-hr. generated		28,400	
Total coal burned, lb.		163,800	
Total water evaporated, lb.		892,500	
Lb. water per lb. coal		5.45	
Lb. water per kw.-hr.		30.4	
Lb. coal per kw.-hr.		5.77	
Average vacuum		27.5	
Boiler number	6	7	8
Flue temperature	.....	.....	530
Draft loss	.....	.....	.....
Feed water temperature:			
To economizer, deg. F.	.....	.....	210
To boiler, deg. F.	.....	.....	260
CO_2 at damper, %	.....	.....	10

Coal Analysis	Moisture as Received	Vol.	F. C.	Ash	B.t.u.
		Dry Basis			
Average per month	.....	.....	.....	.....	.....
Ash analysis, average month	.....	.....	.....	.....	.....

It will be noticed that the water per kilowatt-hour is high, showing that herein lies a part of the trouble. The vacuum is normal, but the turbine load factor is low, which is accounted for by the fact that on this date the total daily output was down to 23,000 kw.-hr. This, of course, is not under the control of the operator, and no one is personally to blame. In the boiler room, under the same date the load factor is unusually low, being an average of 66 per cent. as against the monthly average of 90.88 per cent. The low load necessitated carrying lighter fires than usual and is reflected in the low average CO_2 for that day as well as the low flue temperature. It is obvious that to hold down the boiler capacity the firemen carried shorter fires than usual.

Referring again to the daily report for June 22, a marked rise will be noticed in the pounds of water per kilowatt-hour, although the coal per kilowatt-hour is normal. Inasmuch as the water per pound of coal is high, it would indicate that the boiler efficiency on that date had been good, but that the trouble was in the turbine room.

Looking at the boiler load factor, we find that it was somewhat lower than the average, and the daily report indicates that all three boilers were in service that day. It is apparent that the engineer anticipated a heavy load and had prepared for it by placing another boiler in service. The load proved to be sufficiently large to permit him to run good fires with an average of 10 per cent. CO_2 and a flue temperature of 530 deg. The water evaporated per pound of coal, as previously noted, confirms the satisfactory condition in the boiler room.

In the turbine room the load factor is unusually low, being less than 50 per cent. The placing in service of an

additional turbine for 14½ hr. for that day lowered this figure and caused an increase in the water consumption, which is reflected directly in the curve of water per kilowatt-hour. It is obvious that if this turbine had not been put in service on this day, the coal per kilowatt-hour would have been reduced to a satisfactory figure.

It is in this way that we analyze the various conditions and arrive at a conclusion as to the responsibility for any increase. Should the increase be due to poor judgment in the distribution of the load, steps are taken to rectify it.

In direct comparison to the results on June 22 are the data obtained on the previous day. Here the turbine load factor was relatively high and the water rate consequently low. The total station output was only slightly lower than the following day, but the better turbine load factor is reflected directly in the lower number of pounds of coal per kilowatt-hour.

This plant is under the general supervision of T. E. Rust, chief engineer, and J. B. Willson, operating engineer.

The Capacities of Chimneys

By George A. Orrok*

SYNOPSIS—Factors that influence the capacity of chimneys are explained, and formulas for capacity by many authorities are given.

Theoretically the draft power of a stack depends on the height of its top above the furnace and the respective densities of the hot products of combustion and the outside air. This draft power is usually measured in inches of water by means of a U-tube water gage.

Let H be the height of the stack top above the grates in feet, t the temperature of the outside air, t_2 the temperature of the flue gases and h the theoretical draft power in inches; 62.4 lb. the weight of a cubic foot of water and 0.0807 lb. the weight of a cubic foot of dry air at 32 deg. and 29.92 in. barometer; neglect the humidity of both the air and flue gases, as well as the slight differences in specific gravity.

We have a column of warm flue gases in the chimney of a height H and a column of outside air of the same height. The difference in weight of the two columns may be measured by the U-tube water gage, and the theoretical draft power will be the difference in the water levels in the U-tube. Take 62 deg. F. as the average temperature of the air. The weight of a cubic foot of air at this temperature will be found by multiplying the weight at 32 deg. by the absolute temperature at 32 deg., or 459.6 + 32 = 491.6 deg., and dividing this product by the absolute temperature corresponding to 62 deg., or $\frac{0.0802 \times (32 + 459.6)}{62 + 459.6}$. In a similar manner the weight of the flue gases at 600 deg. (459.6 + 600 = 1,059.6 deg. abs.) may be found. The difference between these weights multiplied by the height H will give the draft power in pounds per square foot. A foot of water is equal to a pressure of 62.4 lb. per sq.ft. and an inch of water to $\frac{62.4}{12} = 5.2$ lb. per sq.ft. Divide by 5.2 to get the draft power in inches of water. This formula may be written for general use by the engineer as follows:

$$h = 0.255\ BH\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

where B is the height of the barometer in inches of mercury and T_1 and T_2 the respective absolute temperatures of the outside air and the flue gases.

*Engineer of construction, New York Edison Co.

With standard barometer, 29.92 in., and the temperatures as given, the formula reduces to $h = 0.0074\ H$, on which the following table is based.

H	h	H	h	H	h	H	h
10	0.074	60	0.444	110	0.814	160	1.185
20	0.148	70	0.518	120	0.888	170	1.260
30	0.222	80	0.592	130	0.962	180	1.330
40	0.296	90	0.666	140	1.037	190	1.410
50	0.370	100	0.740	150	1.110	200	1.480

Many minor variables have been neglected in the formula given, but the errors tend to neutralize one another and the formula is close enough for practical work. It is exact only when no flow takes place. When the chimney is discharging gases, the theoretical draft is lowered by the draft necessary to maintain the velocity of flow, the velocity head plus the friction head. The velocity head may be calculated by the formula,

$$\textit{Velocity head } h = \frac{\left(\frac{0.0807 \times T_{32}}{T_{600}}\right) V^2}{2g \times 5.2} = 0.000114\ V^2$$

and for ordinary chimney velocities up to 30 ft. per sec. will not exceed 0.1 in. of water. The friction head is given by the formula,

$$hf = 0.008\ \frac{H}{D}\left(\frac{V^2}{T_{600}}\right)$$

where D is the stack diameter in feet and T_{600} the absolute temperature of the flue gases. The friction head in stacks of ordinary dimensions is never large, but may amount with a 3-ft. diameter stack and 30-ft. velocity to 0.2 in. of water.

Gale showed ("Trans. A. S. M. E.," Vol. II) that there was a decrease of theoretical draft due to friction, the cooling action of the walls of the chimney (that is, radiation) and leaking of cold air into the stack. In Babcock's discussion of Gale's paper he showed that with a quiet atmosphere the theoretical draft may be largely increased, owing to the column of heated gases above the mouth of the chimney.

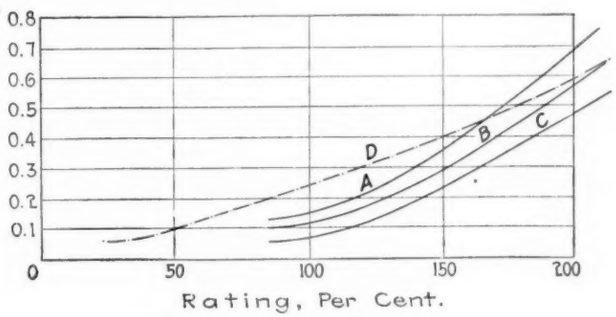
It has long been well known that strong air currents passing over the mouth of the stack have the power of increasing or decreasing the draft power, and many chimney tops or "cowls" have been invented to make sure that this action is always additive. The tops of larger chimneys are usually designed with this end in view.

There is no doubt that the cooling of the gases in the stack due to radiation and leakage lessens the draft power, and Weymouth ("Trans. A. S. M. E.," Vol. 34) modifies the draft formula by introducing a coëfficient f whose value depends on the material of the chimney,

the radiation losses and rate of cooling of the gases in the stack. His formula is $h_r = fKH$, where h_r is the reduced theoretical draft power and $K = 0.0074$. His values of f are: Unlined steel stacks, $f = 0.95$; chimneys with low velocity and large radiating surface, $f = 0.85$.

However, it seems unimportant to go into refinements in calculating draft power when there are so many extraneous circumstances affecting it whose valuation is difficult, not to say impossible.

As the chimney must furnish sufficient draft to burn the fuel as well as to remove the products of combustion, the required draft can be calculated if the design of the grates, boilers and flues be known, together with the kind of fuel to be burned and its quantity. The required draft is made up of the loss of head due to friction in ashpit air-admission openings, to friction in passing through grate and fuel bed, to losses by leakage of cold air into boiler setting, to friction in boiler passes, tubes and chambers, and finally, to flue, economizer and stack friction and the head necessary to produce the flow in the system. Of this total head, the loss due to the grate and fuel bed amounts to from 50 to 75 per cent. The loss from leakage of cold air into the system, from friction in the boiler passes, flues, economizer and stacks may amount to from 15 to 25 per



DRAFT RESISTANCE, B & W BOILERS

Measured in inches of water at third pass; A for 604 hp.; B for 524 hp.; and C for 260 hp. boiler, oil burning; D for coal.

cent., leaving often as little as 6 per cent. to produce the velocity in the products of combustion.

There have been numerous attempts to calculate the draft requirements. Thurston, for instance, gives the following formulas, where c = the pounds of coal burned per hour per square foot of grate surface: Anthracite coal, $h = 0.001875(c + 1)^2$; best Pennsylvania or Welsh coal, $h = 0.00148c^2$; Pittsburgh or Illinois coal $h = 0.000833c^2$. In these formulas Dr. Thurston has allowed for the various losses up to the limit of ordinary boiler practice at that time, but for modern boilers the allowances are too large.

Weymouth, in the paper already quoted, gives the boiler and furnace drafts for oil firing as a set of curves.

The writer has plotted curve D which Menzin ("Journal A. S. M. E.," January, 1916) gives for a cross-baffled three-pass Edge Moor boiler with coal.

This is the best method of obtaining draft requirements when the data is available and the height of stack can then be taken from the table or calculated by $H = 135.25\ h$.

Natural draft greater than 1.5 in. of water is seldom necessary, and higher intensities can much better be obtained by forced or induced draft. This limits the height of chimneys to about 200 ft., which is perhaps above the economical limit from a cost and construction standpoint.

Chemical and metallurgical plants in the neighborhood of towns require excessively high chimneys to remove the noxious gases, and many stacks have been built exceeding 500 ft.

In most cases the height of the stack is determined by other circumstances than the required draft power. In urban localities the top of the stack must be well above the neighboring structures as well as above the roof of the power house or mill, to avoid creating a nuisance. Neighboring hills, cliffs or other eminences cause air currents that are troublesome to a low stack. It is only in level country locations that one can really choose the stack height from theoretical considerations.

Most chimney formulas are based on the hypothesis that the capacity or theoretical coal consumption of a chimney varies directly as the area (or effective area) and the square root of the height.

Let A = the chimney area in sq.ft. and C = coal consumption in lb. per hr. Then the typical chimney formula may be written $C = KA\sqrt{H}$, where K is a constant. It may also be written $C = K(A - 0.6\sqrt{A})\sqrt{H}$, where $A - 0.6\sqrt{A}$ = the effective area (Kent's formula).

The value of the constant K as given by different authorities varies greatly.

Toldt	K = 5	German metallurgical practice
Frechtl	K = 6.4	German metallurgical practice
Molesworth	K = 9	English mill practice
Ser	K = 9.3	French practice
Hulton	K = 10–16	English practice
Seaton & Rounthwaite	K = 12	Marine work
Henthorn	K = 16.65	American general practice
Kent	K = 16.6	American mill practice
Brinckerhoff	K = 18.1	American practice

An average of thirty stacks of various sizes now doing good work gives $K = 9.4$. An average of three notoriously overworked stacks gave $K = 17.9$.

Ser's figure, $K = 9.3$, was obtained theoretically by allowing for 100 per cent. excess air. Allowing for 50 per cent. excess air over the amount necessary for perfect combustion, which result can readily be obtained today, either with first-class hand firing or by the use of automatic stokers, the constant $K = 12$ will be obtained.

For purposes of design, after the height has been settled by the draft requirements or by other circumstances, the size of stack may be calculated from

$$A = \frac{C}{12\sqrt{H}} \text{ and } D = \sqrt{\frac{C}{9.43\sqrt{H}}}$$

The value C should be the amount of fuel per hour at boiler rating, and the stack will be large enough for a 50 per cent. overload.

The constant $K = 12$ should be used only for brick or brick-lined stacks. When an unlined steel stack is being considered the value of K may be increased to 14 or 15, and for small stacks 16 may be used.

It has been customary to consider in chimney figuring 5 lb. of coal as being used per horsepower, and the formula may be stated thus:

$$\textit{Boiler horsepower} = 2.4\ A\sqrt{H}$$

and Kent's formula becomes

$$\textit{Boiler horsepower} = 3.33(A - 0.6\sqrt{A})\sqrt{H}$$

Weymouth has also given a formula for oil-fired boilers,

$$\textit{Boiler horsepower} = \frac{60^2}{G}\sqrt{d^5}\sqrt{\frac{fKH - D_o}{2.3HT}}$$

in which

G = Pounds chimney gases per boiler horsepower per hour;
d = Diameter in inches;
H = Height in feet;
T = Absolute temperature of gases entering chimney;
f = A constant (see preceding page);
K = A constant = 0.0074 (for the given conditions);
D_o = Draft resistance of boiler, damper and uptake in inches of water.

This formula is more nearly theoretically correct than the simple one previously recommended, but is somewhat troublesome to use in practice. There are a number of other methods of chimney proportioning that have been developed to more nearly represent actual conditions, but all are more involved than the foregoing and require a better knowledge of conditions than can possibly exist before a plant has been put in operation.

[Mr. Orrok has favored us with another article on "The Stability of Chimneys," which will appear in an early issue.—Editor.]

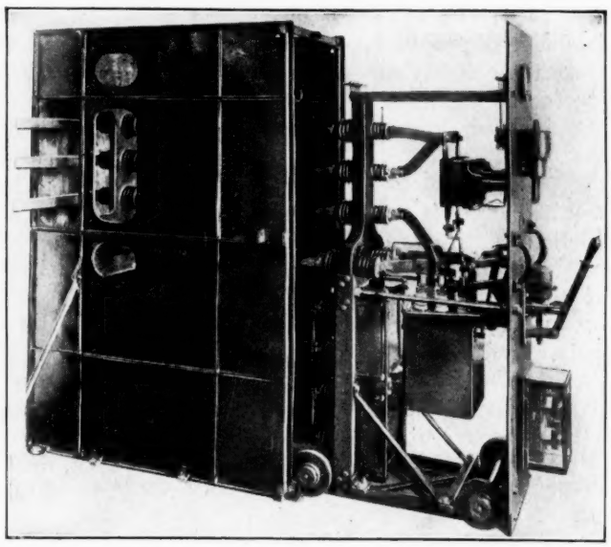
Safety-First Switchboards

In every switchboard installation, protection against accidents should receive careful consideration. This applies particularly to the industrial plant, and doubly so if the panels are mounted in such location that access to them can be had by employees comparatively unfamiliar with electrical devices. To provide ample protection against accident about the switchboard the General Electric Co., Schenectady, N. Y., has recently developed a safety-first truck-type switchboard unit, as shown in the illustration.

All live parts are inclosed, and danger of coming in contact with live circuits is practically eliminated. Oil switches, busses and other live parts are in compartments. This tends to reduce fire hazards and to limit disturbances to a single point. The switchboard panel is mounted on a carriage that can be readily removed from and replaced in the stationary structure, but only when the oil switch is open. With the oil switch closed, it is impossible to remove or insert the truck because of an interlock between the operating toggle of the oil switch and the stationary unit. In plants where feeders are standardized, spare panel trucks will permit systematic inspection of equipment with the least possible interruption of service.

The stationary member of the switchboard carries current and potential busses and disconnecting-switch studs. Barriers between the current-bus studs prevent accidental contact by anyone who enters the compartment. The rear ends of the current-disconnecting-switch studs run to busses and incoming or outgoing leads; the potential-bus wires to small contact studs near the top of the compartment. The side walls have hand holes, so that the bus bars and bus wires can be continued from unit to unit.

The removable truck is mounted on wheels; when withdrawn as shown in the illustration, the equipment is dead and accessible from all sides. The fore part of the truck carries a sheet-steel panel on which are mounted the instruments, meters, oil switches and other appliances, as shown. The current transformers are on steel brackets on the back of the instrument panel. The



SAFETY-FIRST SWITCHBOARD COMPARTMENT SHOWING REMOVABLE TRUCK WITHDRAWN

rear of the truck carries the movable parts of the disconnecting switches, the potential transformers and small-wire accessories. To center the truck and to assist in placing it in or removing it from a compartment, rails are provided for the wheels to run on.

The field of application of standard-size units is limited to 7,500 volts and 2,000 amp. at 60 cycles, and 3,000 amp. at 25 cycles, on the main bus. Special units can be obtained for use up to 15,000 volts and 300 amp. The current capacity of the removable element is limited to 500 amp. at 2,300 volts and above, and 800 amp. up to 600 volts. The unit illustrated is 76 in. high, 24 in. wide and 52 in. deep.

A Bell-Ringing Transformer

By J. Gintz, Jr.

A bell-ringing transformer is nothing more than a step-down transformer on a small scale. The following is a description for making a transformer to step down from 110 volts to approximately 3, 6 and 10 volts, depending on which terminals are used on the secondary.

First a spool is made to wind the coils on. This can be done by using a piece of $\frac{1}{16}$-in. fiber tube 1 in. inside diameter $4\frac{1}{4}$ in. long. Two $\frac{1}{8}$-in. fiber washers $2\frac{11}{16}$ in. outside diameter are placed on the ends of the tube. The various dimensions are shown on the assembled spool, Fig. 1.

After the spool is complete, the core may be placed in it. This is made of soft-iron wire about No. 18 B. & S. gage, cut in pieces 14 in. long. The core should be very carefully assembled to get as much iron as possible in it, and should extend out equal distances from each end of the spool, as in Fig. 2. About 4 lb. of iron wire is required.

The secondary winding is placed on the spool first and consists of 120 turns of No. 12 double-cotton-covered magnet wire wound in three layers of 40 turns each. There are three leads coming from the secondary winding—one from the beginning and ending and one from between the first and second layers. This will bring two at one end, and one at the other as shown in Fig. 2. The voltage combinations are shown in Fig. 3. One pound of wire is required for this winding.

The primary winding is wound on top of the secondary and contains 1,280 turns of No. 23 double-cotton-covered magnet wire, placed in 10 layers of 128 turns per layer.

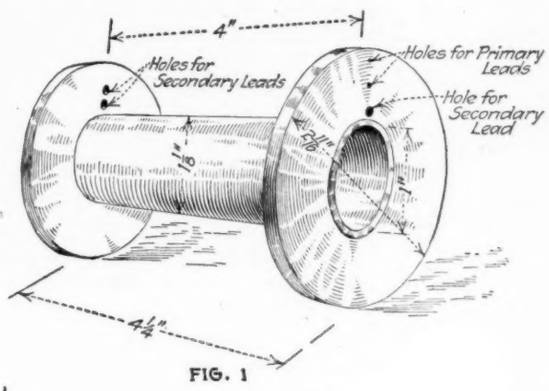


FIG. 1

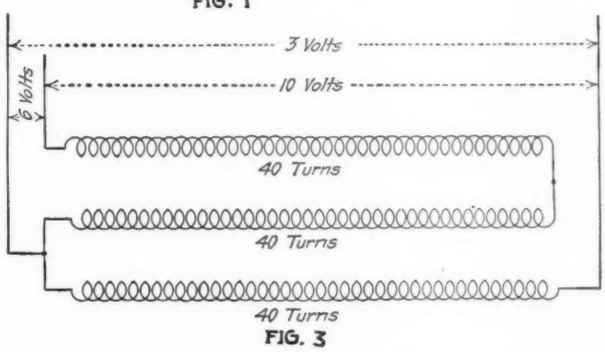


FIG. 3

This winding requires 1½ lb. of wire. Place a layer of thin wax paper between each layer of both primary and secondary winding and three layers between the primary and secondary winding. This is to prevent breaking down between layers and also between windings.

When the primary winding is complete, the outside should be covered with three layers of wax paper and this covered with tape. Then both ends of the core are bent back over the winding, as in Fig. 4. This should be carefully done so that the wires will fit down tight, to eliminate as far as possible air gaps in the core. The whole device is now thoroughly covered with tape and is then ready for operation. Where the leads come out through the core, they should be thoroughly insulated. The transformer should be placed in a neat box made of noninflammable material, the leads from the windings connected to suitable terminals and the box filled with asphaltum or paraffin wax. This device may be used to operate electric bells, electric toys, etc., and has a capacity of about 100 watts.

Russia's Available Water Power in Europe, including Finland, the Ural district and the Caucasus, is estimated at 10 million kw., or over 13 million hp., only about one-fortieth of which is at present utilized.—"Russia," by R. Martens & Co.

The Transformer Heated

By E. C. Parham

If a certain alternating voltage be applied to a given length of wire that is stretched straight, the resulting current flow might promptly burn the wire, because the amount of the current will be limited only by the ohmic resistance of the wire, the self-induction being practically negligible. If the same length of wire be wound into a coil of many turns and the same alternating voltage be again applied to it, the chances of burning the wire will be much less, because when the wire is wound into a coil

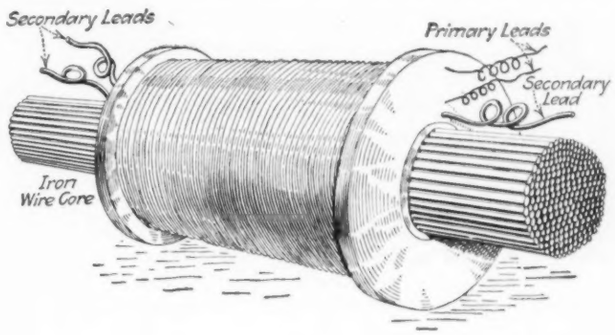


FIG. 2

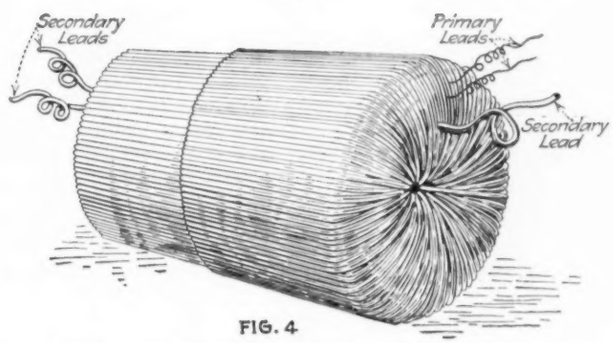


FIG. 4

FIGS. 1 TO 4. PARTS AND ASSEMBLY OF A BELL-RINGING TRANSFORMER

it has a greater self-induction, which helps to limit the current. If an iron core be placed in the coil while the current is flowing and an ammeter be included in the circuit, the current will be observed to decrease, because the iron increases the self-induction of the coil, and therefore the counter electromotive force. Finally, if the iron core be of a hinged construction so that it can be opened, passed through the coil and closed, thereby completing the magnetic circuit, the current will be further reduced, because the lines of force of each turn then can include nearly all the other turns, and the counter electromotive force will be greater than under any of the progressive conditions just named.

Now, if a stout copper ring be slipped over the coil so that the single short-circuited turn lies in the same general direction as do the turns of the coil and the same alternating voltage be applied to the terminals of the coil, the current will again become abnormal, because the single short-circuited turn becomes in effect the short-circuited secondary of a constant-potential transformer. The current in the ring will be large, and the lines of force due to it will neutralize those of the primary coil, thereby decreasing the counter electromotive force of the primary and increasing the primary current.

Of three single-phase transformers that were connected three-phase closed delta, one heated much more than the other two. Inspection indicated the tap connections to be correct, so the element was lifted from the tank for further investigation. It was found that the insulation of the core fastenings had so shifted as to cease to insulate them from the core laminations. The result was to provide a comparatively low resistance iron secondary circuit the magnetism of which partly neutralized the primary magnetism and caused the magnetizing current of that transformer to be much higher than that of either of the two others. It is probable that most of the increase was due to the increased eddy currents incident to the laminations being connected together by the fault.

It was learned that, while unloading the transformers, the one that was giving trouble had been dropped, causing the core fastenings and the laminations to be shifted out of place. They had been straightened and realigned, but the matter of insulation had been overlooked.

Gravity, Weight and Volume of Petroleum Oils

The following tables are reproduced from Bulletin No. 57 of the United States Bureau of Standards, entitled "United States Standard Tables for Petroleum Oils." In addition to those reproduced there are: Table 1, which gives the specific gravity at 60 deg. F. as compared with water at the same temperature of oils having, at the designated temperatures, the observed specific gravities indicated; Table 2, which shows the degrees Baumé at 60 deg. F. of oils having, at the designated temperatures, the observed degrees Baumé indicated; and Table 3, which shows the volume that would be occupied at 60 deg. F. by a quantity of oil, of various specific gravities, occupying unit volume at the designated temperatures.

The first four columns in the following tabulation are selections from the more extended Table 4 in the pamphlet, which gives the degrees Baumé, pounds per gallon and gallons per pound for each $\frac{1}{100}$ variation in specific gravity. Table 5, from which the remaining eight columns herewith were selected, gives specific gravities, pounds per gallon and gallons per pound for each $\frac{1}{10}$ deg. Baumé from 10 to 100 deg.

Copies of this publication may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 15c. each.

Specific Gravity 60°/60° F.	Degrees Baumé. (Modulus 140).	Pounds per Gallon.	Gallons per Pound.	Degrees Baumé (Modulus 140).	Specific gravity 60°/60° F.	Pounds per gallon.	Gallons per pound.	Degrees Baumé (Modulus 140).	Specific gravity 60°/60° F.	Pounds per gallon.	Gallons per pound.
0.600	103.33	4.993	0.2003	10.0	1.0000	8.328	0.1201	55.0	0.7568	6.300	0.1587
.610	99.51	5.076	.1970	11.0	.9929	8.269	.1209	56.0	.7527	6.266	.1596
.620	95.81	5.160	.1938	12.0	.9859	8.211	.1218	57.0	.7487	6.233	.1604
.630	92.22	5.243	1907	13.0	9790	8.153	.1227	58.0	.7447	6.199	.1613
.640	88.75	5.326	.1877	14.0	.9722	8.096	.1235	59.0	.7407	6.166	.1622
.650	85.38	5.410	.1848	15.0	.9655	8.041	1244	60.0	.7368	6.134	.1630
.660	82.12	5.493	.1820	16.0	.9589	7.986	.1252	61.0	.7330	6.102	.1639
.670	78.96	5.577	.1793	17.0	9524	7.931	.1261	62.0	.7292	6.070	.1647
.680	75.88	5.660	.1767	18.0	.9459	7.877	.1270	63.0	.7254	6.038	.1656
.690	72.90	5.743	.1741	19.0	.9396	7 825	1278	64.0	.7216	6.007	.1665
.700	70.00	5.827	.1716	20.0	9333	7.772	.1287	65.0	7179	5.976	.1673
710	67.18	5.910	.1692	21.0	.9272	7.721	.1295	66.0	.7143	5.946	.1682
.720	64.44	5.994	.1668	22.0	9211	7.670	.1304	67.0	7107	5.916	.1690
.730	61.78	6.077	.1646	23.0	.9150	7.620	.1313	68.0	.7071	5.886	.1699
.740	59.19	6.160	.1623	24.0	.9091	7.570	1321	69.0	7035	5.856	.1708
.750	56.67	6.244	.1602	25.0	9032	7.522	.1330	70.0	7000	5.827	.1716
.760	54.21	6.327	.1580	26.0	8974	7.473	1338	71.0	.6965	5.798	.1725
.770	51.82	6.410	.1560	27.0	.8917	7.425	.1347	72.0	.6931	5.769	.1733
.780	49.49	6.494	.1540	28.0	.8861	7.378	.1355	73.0	6897	5.741	.1742
.790	47.22	6.577	.1520	29.0	.8805	7.332	.1364	74.0	.6863	5.712	.1751
.800	45.00	6.661	.1501	30.0	8750	7.286	.1373	75.0	.6829	5.685	.1759
.810	42.84	6.744	.1483	31.0	.8696	7.241	1381	76.0	.6796	5.657	.1768
.820	40.73	6.827	.1465	32.0	8642	7.196	.1390	77.0	.6763	5.629	.1776
.830	38.68	6.911	.1447	33.0	.8589	7.152	.1398	78.0	.6731	5.602	1785
840	36.67	6.994	.1430	34.0	.8537	7 108	.1407	79.0	.6699	5.576	.1793
.850	34.71	7.078	.1413	35.0	.8485	7.065	1415	80.0	.6667	5.549	.1802
.860	32.79	7.161	.1396	36.0	.8434	7.022	.1424	81.0	.6635	5.522	.1811
.870	30.92	7.244	.1380	37.0	.8383	6.980	1433	82.0	.6604	5.497	.1819
.880	29.09	7.328	.1365	38.0	.8333	6.939	1441	83.0	.6573	5.471	.1828
890	27.30	7.411	.1349	39.0	.8284	6.898	.1450	84.0	.6542	5.445	.1837
.900	25.56	7.494	.1334	40.0	.8235	6.857	.1459	85.0	.6512	5.420	.1845
.910	23.85	7.578	.1320	41.0	.8187	6.817	.1467	86.0	.6482	5.395	.1854
.920	22.17	7.661	.1305	42.0	.8140	6.777	1476	87.0	.6452	5.370	.1862
.930	20.54	7.745	.1291	43.0	.8092	6.738	.1484	88.0	.6422	5.345	.1871
.940	18.94	7.822	.1278	44.0	.8046	6.699	1493	89.0	6393	5.320	.1880
.950	17.37	7.911	.1264	45.0	.8000	6.661	1501	90.0	.6364	5.296	.1888
.960	15.83	7.995	.1251	46.0	.7955	6.623	.1510	91.0	.6335	5.272	.1897
.970	14.33	8.078	.1238	47.0	.7910	6.586	1518	92.0	6306	5.248	.1905
.980	12.86	8.162	.1225	48.0	7865	6.548	.1527	93.0	.6278	5.225	.1914
.990	11.41	8.245	.1213	49.0	.7821	6.511	.1536	94.0	.6250	5.201	.1923
1.000	10.00	8.328	.1201	50.0	.7778	6.476	1544	95.0	6222	5.178	.1931
				51.0	.7735	6.440	.1553	96.0	.6195	5.155	.1940
				52.0	7692	6.404	1562	97.0	.6167	5.132	.1949
				53.0	7650	6.369	1570	98.0	.6140	5.110	.1957
				54.0	7609	6.334	1579	99.0	.6114	5.088	.1966
				55.0	.7568	6.300	1587	100.0	.6087	5.066	.1974

Light Converted Into Electricity—In a paper read recently before the New York Electrical Society, Theodore W. Case described a series of experiments whereby electricity was produced directly from the sun's rays. One of the experiments was made with a cell consisting of two oxidized copper plates placed in a solution of common salt and water. The cell was connected to a 200-ohm galvanometer; when one plate was shielded from the light and the other exposed, a deflection of 45 to 50 deg. was obtained on the instrument. Another cell, 3x4 in., had one oxidized and one polished plate in a salt solution of 1.005 sp.gr., with the polished plate protected from the light. When the oxidized plate was exposed to bright sunlight, the cell gave a current of 0.0005 of an ampere at 0.1 of a volt. The best results obtained from the experiment were 0.2 amp. at 0.1 volt.

In Condensing Steam it is customary to use about 27 to 30 times as much injection water (by weight) as the steam to be condensed; the temperature of the hot water should not be above 120 deg.

When Packing a Flange or Cylinder with a rubber gasket, all oil and grease should be wiped from the surface of the metal.

Editorials

The Engineers' Memorial at Liverpool

Cheops! Cheops! Who has not read of Cheops? The Great Pyramid, which for fifty-seven centuries has stood at Gizeh, is his. History has sounded his name through the thousands of years, but it never wasted papyrus to jot down the names of the engineers who designed and built those mighty tombs. Search if you will for the names of those who engineered the building of the famous Appian Way. All you will find is that of Claudius Cæcus, the emperor who reigned when the great highway was begun. The world prefers to remember Michaelangelo and Leonardo Da Vinci as artist and painter rather than as architect and engineer. 'Tis plebeian to plan manual labor or to do it. That is why the magnificent Albert Memorial bears scarcely any but the names of painters and sculptors.

Nestled among the trees in Washington Park at Newark, New Jersey, is the statue of an inventor, hammer in hand, standing beside an anvil. The thing strikes the visitor as so unusual that he feels impelled to get close enough to read the inscription.

City squares and parks are seldom embellished with such works of art, and this makes more gratifying the beautiful monument to engineers erected at Liverpool and shown elsewhere in this issue. Ships, naval and merchant, that have gone to depths untroubled by the tread of human feet have usually taken to Davy Jones' locker their engine- and boiler-room crews. The monument at Liverpool is indeed a fitting memorial to these men.

Selecting Coal

After you have sifted the subject down, you conclude that the coal that will evaporate the most water per unit of total cost is the best coal for the conditions. But many factors influence this result, and each demands particular attention. The selection of coal is therefore not the simple thing that so many large consumers would lead one to believe, despite all that has been written and spoken on the subject. The ruthless waste of coal may quite correctly be attributed to our unequaled wealth in that fuel; also, were it not for the steam turbine's superior economy together with the wave of efficiency in production of shop commodities that has swept the United States particularly, it is likely that coal purchases, even by many of the large users, would still be made in the orthodox hit-or-miss way.

The management of most large plants buy coal with scientific precision as regards its value to the plant conditions. It is the medium- and small-size plants that delude themselves by thinking that efficient buying is unnecessary because the consumption is so much less than that of large central stations or industrial plants.

Elsewhere in this issue appears an article on coal selection that is particularly adapted to small- and medium-sized plants. The author considers the various factors influencing the transportation, storage and combustion. Many of our readers can profitably apply what the article points out.

Saving in the Boiler Room

The big opportunity for reducing costs lies in the boiler plant. This has been reiterated so often that it is difficult to understand how anyone concerned with the operation of a power plant can still fail to realize it. Nevertheless companies continue to hire unskilled firemen who waste several times the difference between their wages and those of more competent firemen. The usual conditions under which a fireman labors are such that a man of brains is not attracted to the work. It is unfortunate that a man with enough wit to be a good fireman is too wise to stay at such employment. Yet it could be highly interesting and a satisfying occupation from the possible results that can be obtained when efficient combustion is made a real study, if only the conditions under which the average fireman has to work were made more comfortable.

That it is a hard, dirty, hot job is the common opinion of firing, and so it is all too often. Consequently it is difficult to get anyone to engage in it that does not feel compelled to for want of knowledge or skill to do something more congenial. Every boiler plant could and should be ventilated so that it is comparatively cool and rid of its gaseous, dusty atmosphere. If it is of any size, it is profitably possible to do away with the irksome task of firing by using stokers and providing ash- and coal-handling facilities. Given these two corrections of the conditions, and men can be induced to fire if they are paid an adequate wage, and they are well worth the better pay if they know how to save coal. Having men who know how, it only remains to put in a few inexpensive pieces of apparatus so that they can tell when they are accomplishing the wanted results.

No one would expect the electrical end of a plant to be operated satisfactorily without some instruments to guide the operators. Yet the pressure gage and the water column have been and are about all the average boiler attendant has to help him. For the rest he is supposed to be able to get along by using his eyes to judge the condition of the fire. There are some men naturally gifted who can do fairly well under even these circumstances, but why leave to human judgment a problem that is easily simplified until it is no trick at all, by providing a few thermometers, a steam-flow meter and a draft gage? A CO_2 recorder or an Orsat is also desirable, although one can get along without such a device after the proper relations between the readings of the other instruments are once established so that efficient combustion can be obtained under all the different changes of load, grade of fuel, and so forth.

There is nothing mysterious about burning coal so as to get the most heat out of it where and when it will do the most in turning water into steam, but it cannot be done continuously and consistently without the means mentioned to show the fireman when it has happened, and if it has not, why. First of all let the boiler room be made fit to live in, then good firemen or men capable of becoming such under proper instruction will be willing to work there. If they have not the knowledge requisite to the task, no better investment can be made than to engage the services of a specialist in boiler-room economy to train them. Even where instruments are provided, they are useless unless the firemen know how to use them and do use them. There are many plants that have everything in the way of equipment necessary to make possible economical operation, but are securing no good of them because the men either cannot or will not take advantage of them. Before the investment in instruments becomes other than a pure expense, the men must be instructed in interpreting and applying the information they afford and then induced to put what they show to use by being given the incentive of pay on a sliding scale according to the result of their work. The human element must be considered, and above all the boiler room must be a place where the employer or manager is willing to go with his good clothes on.

⁂

Installing Motor Equipment

The subject of the proper motor and controller to operate a given piece of apparatus is an important one, and no small amount of attention should be given this matter when selecting a motor to do a given work. The success or failure of the installation may depend entirely upon this decision. It was early recognized in the electrical industry that a universal motor to meet successfully the requirements of any drive is an impossibility. Each condition needs a motor possessing the salient features that are suited to the work. Not alone is the motor to be considered, but the controller must be suited to the load and motor it is to control.

Manufacturers of electrical equipment have made exhaustive investigations to find out the characteristics of the various machines, in order to design their apparatus to meet the requirements of the motor and controller when in service. The results are that today a motor and controller can be obtained which will successfully meet the conditions of any drive, no matter how severe. Not only are electrical machines now designed to meet the working conditions, but also the class of labor that will handle the machines after installation has been given due consideration, and the apparatus is made as nearly foolproof as possible.

The manufacturers, to a very large extent, have done their part, but not infrequently their efforts have been defeated by the location of the motor and controller. If a machine is to give good service, it is not enough that it be of the proper design and have good material and workmanship put into its construction; it must be installed with due regard to its maintenance. It is not uncommon for large outlays of capital to be made for expensive machines and also for the best motors and controllers that can be secured to drive the machinery, but when it comes to installing the motors they are located in some dark corner where it is impossible to give them proper inspection and care without endangering the attendant. Even then some of the important parts of the machine cannot be reached, let alone be seen, without great inconvenience. The result of this mistake is that the machine is neglected, causing a decrease in the reliability of service with a great increase in maintenance charges.

From past experience it seems like poor business, just for the sake of a small saving in space, to install a motor in some out of the way corner where it cannot be given proper attention. Electrical machinery is like any other device. It cannot be expected to give good service continuously if neglected, and the only way that it can be given proper care is by putting it in some place where it can be looked after conveniently.

⁂

Criticizing Superiors Before New Employees

When a new man joins the engineering force of a power plant, it is sometimes a temptation for the old-timers to set forth in no uncertain terms the weaknesses and faults of the "Big Boss" almost before the newcomer has had time to get the first oil spot on his overalls. If the new man appears to be a likable chap, the desire to help him get acquainted with the ins and outs of the establishment is natural enough, but it seldom pays to "knock" one's superiors. No matter how trying it may be to work under some chiefs or superintendents, it is far better to let the new man find it out for himself than to inaugurate a course in disloyalty at the very start of his service.

The old hand is apt to forget that the newcomer invariably approaches his job with an earnest desire to make good, knowing full well that troubles will arise in the work, but determined to satisfy his superiors and render the best possible service. Probably he has talked intimately with the chief before assuming his new duties, and if so, enters the plant either with a feeling of friendliness toward the latter or with a foreknowledge that service under him is going to be difficult. Consequently, if the new man comes into the station favorably inclined toward its head, any volunteered knocks tend to arouse suspicions that perhaps the fellows on the job are "soreheads." Such attacks are likely to put the newcomer immediately in a hostile frame of mind toward the other men. Few things are more destructive of teamwork than covert criticisms.

⁂

There is no item of greater importance in the industrial-preparedness census of the country, now being carried out by the national engineering societies under the direction of the Naval Consulting Board, than that of power supply. This, whether public or private, is the root of all other commodities vital to the country's needs, and in the event of a crisis the knowledge derived from the present investigation would enable the Federal Government to concentrate the supply where most needed, as has been done by Germany and Austria during the present war.

⁂

Paradoxical as it may seem, a cubic foot of wet steam contains more heat units than a cubic foot of dry steam at the same pressure. Proof of this will be found on the inquiries page of this issue. This may explain some of the claims of those who contend that it requires less coal to heat with exhaust steam than with live steam.

Correspondence

The Analysis of Riveted Boiler Joints

The article by Alphonse A. Adler on page 159 of *Power*, Aug. 1 issue is of much interest to those concerned with the design of boiler joints. It appears that a graphical solution of the problem by J. W. Schwedler has been placed in analytical form by the author of the article referred to, and on this account it is difficult to know whether Schwedler fully understood all the questions involved in the design of joints of maximum efficiency or whether Mr. Adler has not fully explained the different features in placing the matter in analytical form.

It would appear from the treatment of the subject in the article by Mr. Adler that it was to be understood that a joint of maximum efficiency could not be arranged with a simple ratio for rivet spacing, from row to row, for it is stated: "The pitch, however, has no simple ratio from row to row, and as a result such joints present no symmetry." The only reason that a joint of maximum efficiency, such as has been treated of in Mr. Adler's article, has the rivets in the different rows unsymmetrically arranged is that the ratio of the crushing strength to the tensile strength is not a whole number. For example, if instead of a tensile strength of 60,000 lb. and a crushing strength of 100,000 lb. a tensile strength of 50,000 lb. had been chosen, with crushing strength of 100,000 lb., then a joint of maximum efficiency would have the rivets arranged as shown in Fig. 1; that is, where the crushing strength is denoted by C and the tensile strength by T, the increase in pitch from row to row is $\frac{C}{T} + 1 = 3$, where the unit values for plate strength are chosen as mentioned.

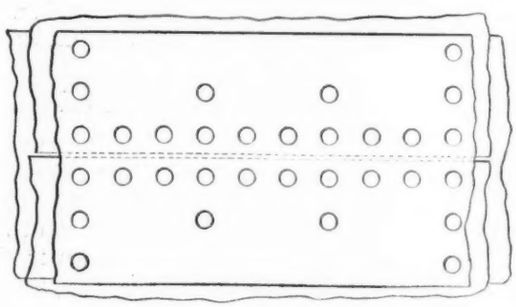


FIG. 1. FORM OF BUTT-STRAP JOINT

Another point in regard to the design of riveted joints of maximum efficiency that is apparently not understood by the author of the article referred to is that there is no need to adopt an odd size of rivet hole in designing such joints, for all that is required is to see that the relation of plate thickness and rivet-hole diameter is such that the rivets cannot shear, but that the plate in front of them will crush.

For example, assume that with $C = 100{,}000$, $T = 60{,}000$ and $S = 45{,}000$, where S represents the shearing strength of the rivet material in single shear in pounds per square inch, it is decided to design a joint of maximum efficiency employing four rows of rivets and with double butt straps; and assume that the plate thickness to be used is ½ in. All that is required in selecting the rivet-hole size is to know that its diameter is equal to or greater than $\frac{tC}{0.7854(2S)}$, where t = the plate thickness; the value $(2S)$ is used because the rivets are in double shear. With the values of t, C and $(2S)$ as given, the rivet-hole size

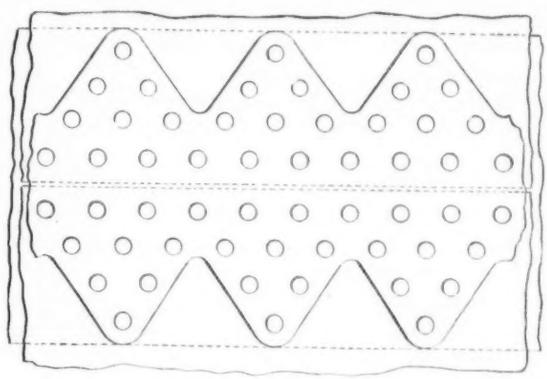


FIG. 2. THE SAW-TOOTH BOILER JOINT

would have to be equal to or greater than 0.7074 in. The next commercial size is ¾ in., but $\frac{15}{16}$ in. or 1 in. may be just as well used in the design of the joint, the only difference being that the spacing of the rivets will be wider apart where the larger sizes of holes are used.

For example, with the ¾-in. rivet holes the pitch on the outer row of a joint of maximum efficiency, where four rows of rivets are used, would be 37.89 in. and if the hole diameter had been 1 in., the pitch on the outer row would be 50.52 in., but the joint efficiency in either case would be 98.02 per cent., which is the maximum efficiency that may be secured by using four rows of rivets where the values of C and T are 100,000 lb. and 60,000 lb. respectively. It is interesting to note that the shearing strength of the rivet material has no bearing on the maximum joint efficiency attainable, this depending entirely on the ratio of the tensile strength to the crushing strength of the plate used. The shearing value determines only the minimum size of rivet hole that may be used to secure a joint of maximum efficiency. While the design of a joint of maximum efficiency is of interest, what is of more importance to the designer is to be able to tell the proper pitch to choose for an arrangement of rivets that has proved to be best suited to the requirements of boiler construction, and it is not often that the joint of the highest efficiency will prove a practical one for use. It is, however, desirable to secure the highest efficiency that may be obtained and have the design practical in other respects. The arrangement of rivets shown in Fig. 2 is one used where it is required to secure a joint of high efficiency with plates of considerable thickness, and this arrangement permits the distance between the rivet holes to be such that calking may be readily applied to the edges of the straps.

Where the value of C is 100,000 and T 60,000, the highest efficiency that may be attained with this arrangement of rivets is 93.75 per cent., and this efficiency may be closely approached over quite a range of plate thickness. With 7/8-in. plate, the rivet-hole diameter required would be 1.238 in. or larger, say 1¼ in.; then the pitch for the highest efficiency would be 20 in.

On account of the fact that joints of highest efficiency do not usually present a practical spacing of rivets for the purpose of boiler design, it is much the best in designing boiler joints to draw a diagram giving the various efficiencies that may be obtained with the arrangement of rivets that has proved best for the purpose, and from such diagrams the joints that are best both from the standpoint of strength and "calkability" may be selected. The writer has made such diagrams for all the commonly used arrangements of rivets in boiler work, and he finds them superior to any analytical method of attacking the problem of determining the best design for boiler joints.

No positive rule may be laid down as a guide in the selection of strap thickness to be used for riveted joints, for it is not the maximum-efficiency joint that necessarily requires the heaviest straps to prevent the strength of the straps at the inner row of rivets from affecting the strength of the joint. It may be readily shown for a joint where the rivets are all in double shear and of the highest efficiency possible, and with $C = 100{,}000$ lb. and $T = 60{,}000$ lb., that if the thickness of each strap is at least 80 per cent. of the plate thickness, the strength of the straps along the inner row of rivets will not affect the strength of the joint.

To show that this statement is true, the efficiency along the inner row of rivets, in a joint of maximum efficiency where C is 100,000 lb. and T 60,000 lb., is 62.5 per cent.; therefore this efficiency times the combined thickness of the straps must equal the plate thickness times the joint efficiency as determined by the failure of the plate at the outer row of rivets. Assuming that a large number of rows of rivets are used and that the joint efficiency is therefore practically 100 per cent., then $0.625 \times 2t_s = 1.00t$ would express the strap thickness required in terms of plate thickness, where t was the plate thickness and t_s the strap thickness. Solving the formula to obtain the value of t_s, it is found that $t_s = 0.8t$; that is, if the strap thickness is equal to or greater than this value, then the strength of the straps at the inner row of rivets cannot reduce the strength of the joint.

The foregoing reasoning is, of course, based on the assumption that the material of which the straps are made is at least equal in strength to the plate.

For joints of maximum efficiency with any number of rows of rivets, the following formulas hold good:

$$P = d\left(\frac{C}{T} + 1\right)^m \qquad E = \frac{P - d}{P}$$

P = Pitch of rivets in the outer row;
d = Rivet-hole diameter;
m = Number of rows of rivets employed in the joint;
E = Joint efficiency;
C = Crushing strength of the plate;
T = Tensile strength of the plate;
S = Shearing strength of the rivet material in single shear;
t = Plate thickness.

With double straps d must be equal to or greater than $\frac{tC}{0.7854(2S)}$.

To determine the spacing on the different rows, assign a value to m that corresponds to the number of the row concerned. For example, on the first row $P = d\left(\frac{C}{T} + 1\right)$ and on the fourth row $P = d\left(\frac{C}{T} + 1\right)^4$.

S. F. Jeter, Chief Engineer,
Hartford Steam Boiler Inspection and Insurance Co.
Hartford, Conn.

Overcoming Wattless

The article by T. J. Burns, entitled "Overcoming Wattless," on page 175 of the Aug. 1 issue of *Power*, is indeed a good one and shows that there are some thoughtful minds in charge of this plant. There is room, however, for Mr. Burns to further overcome considerable wattless as well as relieve his turbo-generator and synchronous condensers of a great strain at starting, by following a slightly different method.

If he will open his main station switch, then connect both of his 2,000-kw. synchronous condensers and his turbo-generator to the bus, exciting the fields of all three machines to about normal and then start his turbo-generator slowly, he will find that the motors will start with the generator and will not take the enormous current these machines usually take when started as induction motors. He will also find that the motors will start in step with the generator and will accelerate smoothly to full speed, when they may be synchronized with the rest of the system as at present.

Mr. Burns' station should be provided with an auxiliary bus so that it would not be necessary to kill the station's main bus to start the synchronous condensers. An auxiliary bus would also make this station more flexible, as he could start either one of his condensers as the load demanded without having to shut down the other one, which might be running on the station bus.

New York City. L. J. La Chance.

Fuel Oil Versus Coal

In view of the recent propaganda urging the use of fuel oil under steam boilers as an economic improvement over the use of coal, the following analysis of a report of one whom we will call Mr. Jones, urging the adoption of oil as fuel for a certain New England industrial power plant which we will call the Blank Manufacturing Co., is interesting.

In view of the recommendations of Mr. Jones, it is interesting to observe that the large electric-power public-service companies of New England have the best consulting electric and steam power-plant engineers at their command, yet do not use oil as fuel for generating steam; and if there were any such savings as is indicated in Mr. Jones' report, they would surely take advantage of it.

While fuel oil is economically useful in many industries, it is not here commercially advisable for purposes of steam generation. There are other disadvantages. For instance, there is hardly enough fuel oil produced to supply steamboats touching at our ports. This point is brought out in the voluminous report of the United States

Liquid Fuel Board. The limited supply of fuel oil would therefore cause a material increase in price should it be used to a large extent for stationary power generation, thus eventually offsetting any economical gain that it possesses at present. Furthermore, it is not always possible or convenient to get fuel oil from the large number of sources from which coal is available. Therefore, the same or greater difficulties regarding the supply prevails as are present where coal is used. Freight embargoes apply to carloads of fuel oil in the same degree that they do to coal. At such times as the present, when it is difficult to obtain regular deliveries of fuel oil or coal, increased storage capacity must be provided to tide over periods of delays. This is more easily provided for coal than for oil. Coal may be stored in any number of accessible vacant places, whereas fuel oil must be stored in properly designed and located tanks, which seldom can be obtained at short notice. Aside from the foregoing evidence and the detailed analysis of the economic use which is to follow, it is interesting to consider the benefits to be derived from the use of oil as summarized by Mr. Jones in his report:

1. Increased capacity from present boiler 25 to 50 per cent.
2. Cleanliness in the boiler room.
3. Flexibility in handling fuel.
4. Automatic regulation of steam pressure within closest limits.
5. Absolute prevention of smoke.

Consider each separately and in the order as mentioned.

1. It may be possible to increase the capacity of the present boilers, but from the statement that appeared in the report of the United States Liquid Fuel Board to the effect that "a fuel-oil furnace may be forced to as great an extent as a coal-fired furnace," it does not appear that there is any great difference in the capacity of boiler plants when fired by oil or coal. Furthermore, it is not reasonable to expect that one furnace will burn more fuel than another, even though that fuel be of a liquid character, provided it is not advisable to maintain a temperature over and above a certain limit and provided furnaces are of proper size and draft to be forced to the extent practicable for the fuel used. The United States Liquid Fuel Board reports that the use of fuel oil under boilers causes the best forms of commercial firebrick to deteriorate rapidly.

2. It is probably true that the boiler room may be more easily kept clean when using the fuel oil than with coal. This is comparatively unimportant.

3. It is probably true that fuel oil tends to make the steam plant more flexible, but here again it does not seem to be of sufficient importance to recommend its adoption unless there is some economic advantage.

4. Automatic and close regulation of steam pressure within close limits is also possible with coal and at a not greatly increased cost.

5. Fuel oil does not absolutely abolish the smoke nuisance as stated. Apropos to this the following is quoted from the conclusions of the Liquid Fuel Board:

> That under severe forced-draft conditions and with water-tube boilers and with the use of oil as a fuel, the solution of the smoke question is nearly as remote as ever. Where a limited quantity of oil is burned in a Scotch boiler, however, and retarders are used in the tubes, the burning of crude petroleum should be smokeless.
>
> Never in the experience of many citizens of Washington had such clouds of smoke been seen coming from a chimney as issued from the boiler stack of the experimental plant when oil tests were conducted under strong forced-draft conditions. The smoke issuing from the stack during certain forced-draft tests was made a matter of official complaint by the civil authorities.
>
> On shore it is possible to approximate to many of the necessary conditions essential for securing complete combustion in the burning of oil, for in the installation of a land boiler there are but few limitations as to weight, floor space or height. In arranging a battery of land boilers there can be effected such an installation that the management of the firing can be absolutely controlled by some intelligent and competent water tender. The height of the stack need be limited only by the judgment of the engineer who designed the plant. And yet on shore the burning of oil, as fuel, in large quantities has been carried on only with extreme difficulty as regards smoke, particularly when there has been an attempt made to force the fires.

The accompanying table contains a detailed analysis of Mr. Jones' report compared with existing conditions. In Column 1 are Mr. Jones' figures and assumptions, and Column 2 includes only actual figures or assumptions made by Mr. Jones on data substantiated by reliable references. It should be observed that there are several discrepancies, and of course the figures given in Column 2 represent the true conditions:

	Items.	Column 1, Mr. Jones' Figures and Assumptions	Column 2, Actual Figures
1.	Heating value of New River coal per lb. approximately, b.t.u.	14,000	14,800 (a)
2.	Cost of coal per ton of 2,240 lb.	$4.80	$4.80
3.	Three firemen at $3 per day	$9.00	$8.64
4.	Two coal passers at $2.50 per day	$5.00	$4.32
5.	Total labor cost per day equals Item 3 + Item 4	$14.00	$12.96
6.	Average quantity coal consumed per 24 hr., tons	18	18
7.	Cost per ton for handling coal equals Item 5 ÷ Item 6	$0.78	$0.72
8.	Cost of removal of ashes per ton of coal	$0.01	$0.01
9.	Total cost per ton of coal and ashes removed	$5.20	$5.14
10	Assumed loss of heat carried away with ash, per cent	6	(b)
11	Assumed loss of combustible lost with ash, per cent	4	5 (c)
12.	Total heat lost with ash equals Item 10 + Item 11, per cent	10	8
13.	Total heat units lost with ash equals Item 1 × Item 12, b.t.u.	1,400	443
14.	Heat available for transmission to boilers equals Item 1 — Item 13, b.t.u.	12,600	14,357 (d)
15.	Assumed heat per pound of fuel oil, b.t.u.	19,500	19,000
16.	Weight of 1 gal. of fuel oil, lb.	7.5	7.5
17.	Gallons of fuel oil per barrel	42	42
18.	Weight of fuel oil per barrel equals Item 16 × Item 17, lb	315	315
19.	Heat per barrel of oil equals Item 15 × Item 18, b.t.u.	6,142,500	5,995,000
20.	Heat in b.t.u. available for transmission to boilers per ton of 2,240 lb. of coal equals Item 14 × 2,240	28,224,000	32,150,000
21	Barrels of oil equivalent to 1 long ton of coal equals Item 2 ÷ Item 19	4.56	4.56
22	Cost of oil per gallon	$0.0245	$0.025
23.	Cost of oil equivalent to 1 long ton of coal equals Item 21 × 42 × Item 22	$4.72	$5.64
24.	Evaporation increased due to oil, per cent.	10	10
25.	Cost of oil required to evaporate an equivalent to the evaporation of 1 long ton of coal equals Item 23 — Item 23 × 0.10	$4.25	$5.05
26.	Two firemen to fire oil at $3 per day (e)	$6.00	$5.76
27.	Cost of handling oil equivalent to 1 ton of coal equals Item 26 ÷ Item 6	$0.33	$0.32
28.	Total cost of oil equivalent to one ton of coal burned and ashes removed equals Item 25 + Item 27	$4.58	$5.37
29.	Excess cost of coal per ton over equivalent of oil or vice versa equals Item 9 — Item 28	coal, $0.62	oil, $0.23
30.	Item 29 expressed in per cent	12	4.28
31.	Heat lost in steam used for atomizing oil, per cent	2	3.39 (f)
32.	Net saving in favor of oil or continued use of coal equals Item 30 — Item 31. For column 2 Item 30 + Item 31, per cent	10	7.67
33.	Total cost of burning coal per month	$2,517.00	$2,517.00
34.	Saving per month in favor of oil equals Item 32 × Item 33	$251.70	
34A.	Saving per month by continued use of coal instead of oil as proposed equals Item 32 × Item 33		$192.00

(a) Mean heating value taken from United States Geological Survey Report, Kent, Sterling and Steam.

(b) Few authorities separate this loss from other radiation losses. Probably it is practically nothing, as it is largely recovered by incoming draft of cold air before it passes through the grate.

(c) Gebhar gives the following value; 0.5 per cent. for excellent, 1 per cent. for good, 2 per cent. for average, 3 per cent. for poor.

(d) This value is a fair mean value taken from a number of sources such as Hutton, Carpenter, and Sterling.

(e) Nothing has been allowed for handling the oil, and something would naturally be charged for this, but oil firing has been given the benefit.

(f) This item in column 2 is obtained under the assumption of 4½ per cent. of steam evaporated and 75 per cent. efficiency of boiler burning fuel oil, board report.

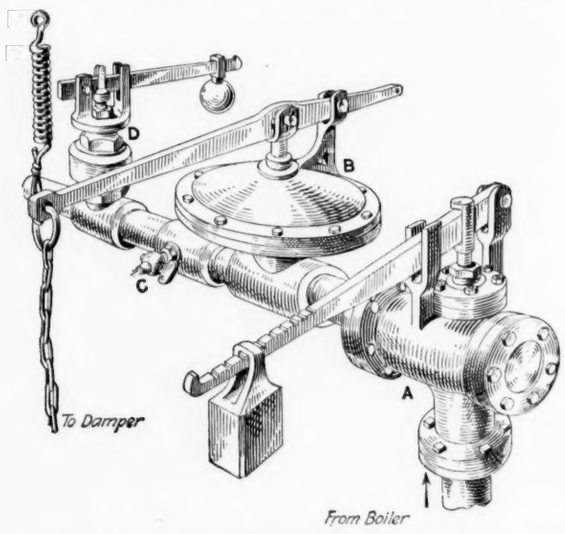
Holyoke, Mass. ROBERT E. NEWCOMB.

[While the report of the Liquid Fuel Board of the United States Navy is one of the most extensive and authoritative works on the subject, the reader should be cautioned against believing, as Mr. Newcomb's letter might lead him to believe, that the United States Navy does not favor oil burning. The Navy has adopted fuel oil for all classes of the service, some of the late vessels not even being provided with coal bunkers. From a purely engineering standpoint, it has been well established that oil burning under boilers is clean and flexible, and, on the whole, economical. If there is any sound reason why oil should not be used at all as fuel, it is because such use tends more quickly to deplete the supply of crudes. For some of the fractional oils, such as gasoline, naphtha, etc., there is a demand which threatens to exceed the supply, considering that Russia, Mexico and the United States are the only world producers.—Editor.]

Low-Pressure Damper Regulator

The illustration shows how a low-pressure diaphragm damper regulator was used on a high-pressure boiler. Valve *A* is a lever safety-valve, *B* a low-pressure regulator taken from a steam heating system, *C* a relief cock and *D* a lightly weighted low-pressure lever safety valve.

The valve *A* is set at the pressure at which the damper should close, so that when it blows, it will raise diaphragm *B*, thus closing the damper through a chain. Pet-cock *C* is left slightly open to let the steam escape and pressure drop when the safety valve *A* closes, thus opening the damper; *D* is used more as a safeguard



PIPE CONNECTION TO HIGH-PRESSURE BOILER

against injuring the diaphragm when the pressure is greater than that which the regulator is intended to sustain.

The safety valve shown is not the regular boiler relief or safety valve, but was put on only for the damper regulator. The whole contrivance was made out of discarded material about the place, but served the purpose very well and saved me a lot of steps during the course of the day.

HENRY F. GRAY

Boston, Mass.

Both the Exciters Had Reversed Polarity

Referring to the article on page 69 of the July 11 issue of *Power*, by Mr. Sykes, it seems that there were no equalizer connections between the compound windings on the exciters, because reversal of polarity under such conditions is impossible if there are equalizer connections in good order. It therefore would seem that the addition of such connections would remove the difficulty.

Of course, because one exciter (or any direct-current shunt or compound generator, for that matter) motors another is no reason why the polarity should be reversed. When two generators are operating in parallel the polarity of the armatures is the same whether they are both furnishing current or whether one is running the other as a motor. Reversal of polarity takes place when a compound-wound generator is motored by another, provided the reversed current in the compound winding has sufficient effect to overcome the effect of the shunt winding. The equalizer connection between the machines prevents this, regardless of whether the machines are flat-compounded or one of them is overcompounded.

Lake Charles, La. H. F. CAMERON.

What Was the Trouble with the Compressor?

In answer to A. C. McHugh's inquiry on page 885 of the June 20 issue, headed "What Was the Trouble with the Compressor?" I offer the following:

The trouble was caused by the suction valve of the crank end sticking, possibly due to wear, a weak spring or to the spring being broken off on the ends, thereby shortening it. The suction valve was kept partly open, and the incoming gas, together with liquid, was churned over and over again.

The crank end would naturally frost over heavily, as there was no outlet for the liquid except by evaporation and by escape back through the open suction valve into the suction pipe. This partly open valve would also account for the blowing sound. Upon closing the equalizer valve in the oil reservoir a pressure was created in the oil chamber around the stuffing-box, caused by the ammonia in the oil being heated and expanded, due to friction of the piston rod.

This pressure caused the oil to be forced back past the packing into the compressor, lubricating the defective suction valve, which started it working satisfactorily.

When the equalizer valve on the oil reservoir was set to one-fourth turn, there was just enough pressure in the oil chamber to force into the crank end of the compressor an amount of oil sufficient to lubricate the suction valve and insure its operation. This valve is evidently defective and should be attended to.

Ordinarily, a valve in good condition will receive enough lubrication from the liquid ammonia passing into the compressor with the gas. Sometimes a trouble such as noticed by Mr. McHugh is caused when an inferior oil is used. This oil will freeze when there is a heavy frost back, and therefore will not lubricate.

It is good practice to regulate the oil equalizer valve so that the pressure in the oil chamber around the stuffing-box is slightly above the pressure in the suction pipe. Then a small amount of oil will always be forced

into the suction pipe, travel along with the gas and lubricate all the valves; but care must be taken not to have this valve closed too much, as the pressure in the oil chamber might get too high and cause the rod to heat, especially when the packing is new.

New York City. WILLIAM SCHLIEMAN.

Packing for Hot Water

The following change in the design of the piston of a hydraulically operated valve may be of interest to readers of *Power*.

The valve is a 30-in. gate controlling the exhaust from a 750-kw. turbine and is operated by a 10-in. hydraulic cylinder. As originally designed, the piston was packed with two cup leathers, one facing in each direction. The only water under sufficient pressure to operate the valve was the boiler feed and, as we have an open feed-water heater, this is of course hot.

Trouble soon developed with the valve, as it opened and closed very slowly, and before long it would not respond at all when the pressure was turned on. Upon examination it was found that the hot water had burned the leather packing until it had almost disappeared.

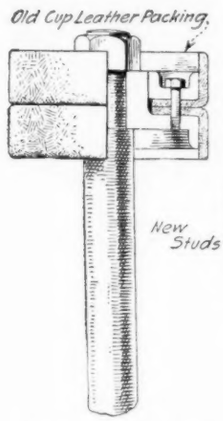


FIG. 1. OLD PISTON

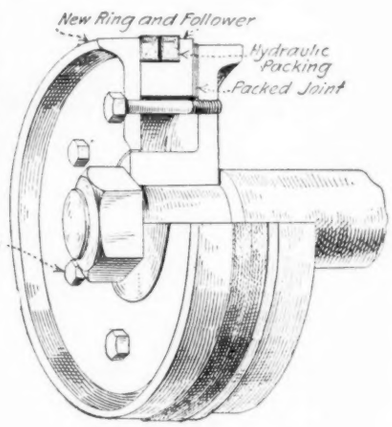


FIG. 2. NEW DESIGN

Fig. 1 shows a sectional view of the piston as originally designed for cup leather packing, and Fig. 2 the changed construction consisting of a cast-iron ring to slip over the follower studs, turned to form a shoulder for two rings of ⅜-in. duck packing, and a new follower having a flange about 2½ in. wide to furnish a bearing on the cylinder.

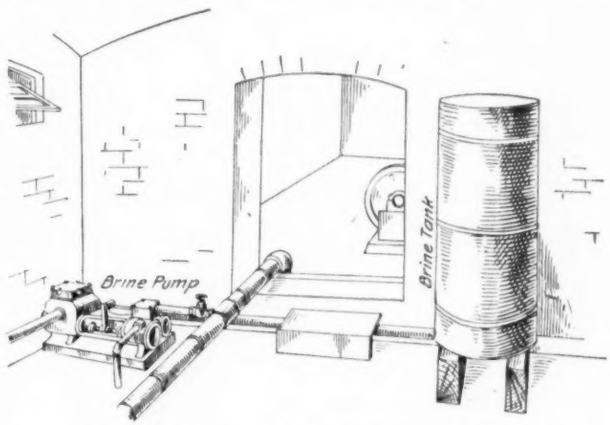
The valve has been operated daily for the past 9 months and has given no trouble whatever. The ring and follower were made at a local shop at a cost of $12.50.

Ithaca, N. Y. C. B. HUDSON.

Badly Located Machinery

It is strange that many architects and consulting engineers when drawing up the plans for a new building seem to consider any out of the way corner of the basement good enough to house the power plant, which is really the heart of the whole structure. More attention is being paid to this matter now than was formerly the case, and we may hope that the days of poorly located machinery in isolated plants will soon be over. That day has not yet arrived, however, as the illustration shows.

A pump located in one corner of the ice room in the power plant of a large apartment building was mounted on a concrete foundation with one end only a few inches from the brick wall of the building. The brine tank on the opposite side of the doorway had plenty of space all around it. When it became necessary to renew the bushings of the brine cylinders, the trouble began. It was



ORIGINAL CRAMPED POSITION OF PUMP

necessary to disconnect all the steam and brine piping and remove the pump from its foundation. It was therefore decided to place the pump in a better position by exchanging the locations of the pump and the brine tank. Only slight alterations in the piping were necessary. The piping and the pump are now easy to get at for inspection and repair; and should the bushings again need renewing, they can be removed without in any way disturbing the piping. HUGH G. BOUTELL.

Philadelphia, Penn.

Centrifugal Boiler-Feed Pump

The factors tending to cause centrifugal boiler-feed pumps to displace the piston and plunger type pumps are increased duty, lower maintenace costs, less floor space and greater operating flexibility.

Troubles with centrifugal pumps are often due to the fact that the engineer does not know the few important fundamental laws governing their design and operation. These fundamental laws may be stated as follows:

With a constant head the capacity will vary as the square of the speed.

With a constant speed the capacity will vary inversely as the square of the head.

The head is proportional to the square of the speed, the volume being proportional to the speed.

The quotient of the radial velocity of flow divided by the peripheral velocity should be approximately 0.135.

It is common practice to equip pumps with pressure regulators, and the small water line to the regulator is often connected to a point too near the pump discharge, and as a result the discharge pressure of the pump is very irregular, causing a slug action. But if this connection is tapped off an auxiliary header or off the main boiler-feed line at considerable distance from the pump, the pressure maintained by the pump will be quite uniform.

Considerable improvement has been made during the past few years in the efficiency, or number of foot-pounds

duty obtained from boiler-feed pumps per 1,000 lb. of steam, as shown by the test reports following:

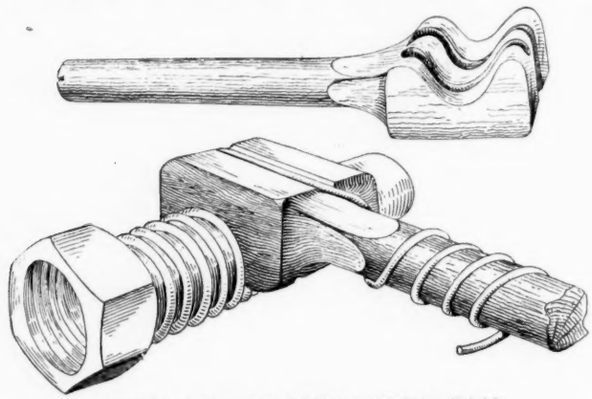
Test A was made in 1906 on an 18x12x16 horizontal duplex plunger pump operating at 50 ft. piston speed; B, 1912, centrifugal feed pump, 2,020 r.p.m., 500 gal. per min.; C, 1915, centrifugal feed pump, 3,030 r.p.m., 500 gal. per min.; D, 1915, centrifugal feed pump, 2,150 r.p.m., 1,200 gal. per min.

	A	B	C	D
Steam pressure, lb....	200	184	184	200
Discharge pressure, lb.	240	264	251	260
Temperature of pump delivery, deg. F.....	212	208	177	208
Suction head, lb.....	3.5	3.5	8	3.5
Gal. per min.....	500	520	486	1,290
Steam consumption ..	8,600	8,250	4,550	8,175
Water hp.	63	80	71	195
Duty, ft.-lb. per 1,000 lb. steam	14,600,000	19,200,000	30,800,000	47,400,000

Jersey City, N. J. J. D. MORGAN.

Useful Hose-Binding Tool

A handy hose-binding tool can be made by taking a block of hardwood about 15 in. long and 2½ in. square and shaping it as shown in the illustration. Grooves can



APPLICATION OF HOSE-BINDING TOOL

be cut or turned in the handle for wire ways if necessary. This handle will keep the wire taut through the process of winding. It is especially useful to steam fitters and engineers when inserting nozzles or nipples of steam apparatus in rubber hose to hold them tight.

Chicago, Ill. F. F. SENGSTOCK.

An Uneconomical Installation

Some time ago I was called into a manufacturing plant to make a test on some motors for current consumption. What interested me more than anything else was the condition under which two 5-hp. machines were operating. After taking meter readings as indicated in the illustration, the results obtained were as shown. The pressure drop across the controller when in normal running position (which in this case was on the first point) was almost equal to that across the armature terminals.

The watts (W_r) expended in the resistance equals the drop (E_r) across the resistance times the armature current (I); that is, $W_r = E_r I = 115 \times 11.8 = 1{,}357$ watts. The watts (W_a) expended in the armature equals the volts (E_a) impressed on the armature terminals times the armature current (I), or, $W_a = E_a I = 122 \times 11.8 = 1{,}440$ watts. Here was a case where they were taking $W = EI = 237 \times 11.8 = 2{,}797$ watts from the line to supply 1,440 watts to the armature of the motor. This naturally suggested that the power consumption and consequently the cost of operating the two machines might be approximately cut in half by installing the proper drive.

The conditions were such that the speed could not be changed by changing the pulleys on the machines or motors, and as the latter were approximately three times as large as were necessary to do the work, it suggested a new motor of the proper size. The actual size of the motor necessary to do this work is found by the formula:

$$Horsepower = \frac{W \times per\ cent.\ eff.}{746} = \frac{1{,}440 \times 0.75}{746} = 1.45$$

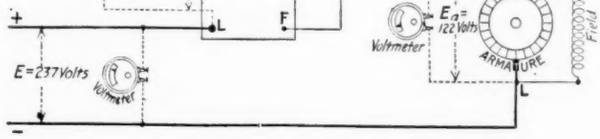
Where W equals the watts expended in the motor, the percentage of efficiency for a 5-hp. motor carrying the foregoing load is approximately 75 per cent., and 746 is the watts per electrical horsepower. As can be seen, a 2-hp. motor would be sufficient to do the work, and this was the size recommended for the job.

The speed of the 5-hp. motors was taken and found to be 925 r.p.m. (this should be the speed of the new motors), when they actually should have been running at approximately 1,700 r.p.m. as marked on the nameplate. Standard 2-hp. motors are not built to run at 925 r.p.m., consequently, a 850-r.p.m. machine was selected, as this is a standard speed for a machine of this size. The difference between this speed and that required could be taken care of by increasing the size of the motor pulley.

The approximate saving in changing the motors may be found by the following: There was an actual loss of 1,357 watts in the resistance in series with each machine; this was going on all the time that the motors were in service, which in this case was about 5 hr. per day, 26 days per month, or $26 \times 5 = 130$ hr. per month. The kilowatt-hour loss per month equals the watts loss (W_r) times the number of hours per month (T) divided by 1,000; from which

$$Kilowatt\text{-}hours = \frac{W_r T}{1{,}000} = \frac{1{,}375 \times 130}{1{,}000} = 178.8$$

Multiplying this by the cost per kilowatt-hour, which in this case averaged about 6c., will give the unnecessary



WHERE METER READINGS WERE TAKEN

cost for operating one motor with the resistance in the circuit; that is, $178.8 \times 0.06 = \$10.73$. For the two motors it would be $\$10.73 \times 2 = \$21.46$ per month. Two new machines of the latest type, proper size and speed could be installed for about $330; therefore the new motors will pay for themselves in $\frac{330}{21.46} = 15$ months, not considering what could be realized on the old machine.

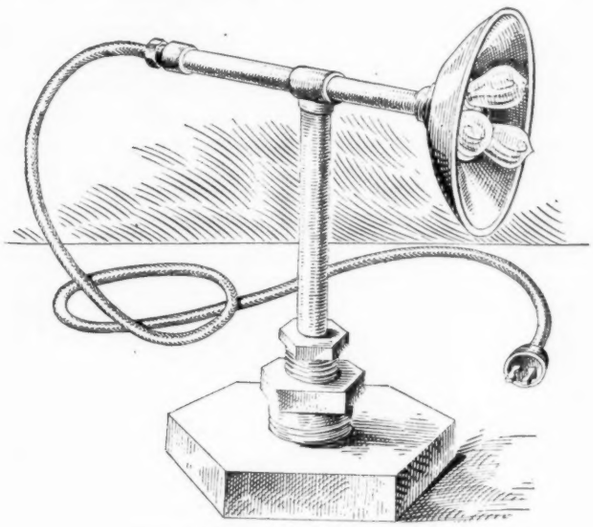
B. A. BRIGGS.

New York, N. Y.

Catch Plates on a Corliss Engine should be adjusted so as to give them sufficient surface on their working edges, and they will wear longer. Also it should be seen that the working edges strike each other squarely. If the springs are weak, they can be strengthened by carefully pressing the ends toward each other in a vise, or a new set of springs can be secured.

Handy Lamp Extension

A handy lamp extension can be made by tapping a piece of ½-in. conduit pipe and screwing one end into a number of reducers or using some form of weight, as shown. At the other end place a ½-in. pipe tee, using



HOME-MADE PORTABLE LAMP

also two nipples 4 in. long. On one of the nipples fasten a three-light cluster securing a metal shade at the back of it by means of a locknut. The other nipple is fitted with a brass reducing plug to which is fastened the portable cord or armored cable having a plug connection at its other end.

F. F. Sengstock.

Chicago, Ill.

Effect of Sulphur in Steel

I read with interest the summary of Dr. Unger's article in the issue of July 25, on the sulphur content in steel and the editorial comment in the same issue. It would be presumptious for me to attempt a criticism of an opinion on this subject by such an authority, but from many years' experience in rolling mills it may not be out of place to suggest that he seems to have omitted tests under the conditions in which the harmful effects of sulphur in steel would be manifest.

In rolling-mill parlance the terms hot-short and red-short are synonyms and refer to a condition under which the iron or steel will disintegrate, crack or break off short at a critical temperature while being rolled or otherwise worked. Sulphur may not affect the quality of steel when cold or while being worked at temperatures under which the metal will flow readily under pressure, but the presence of sulphur in some form affects the working properties at the period when the metal is passing from the semifluid to the solid state—at least, such is the common experience. According to various authorities on this point, the working temperature at the finishing end of a rolling mill is that of a free scaling heat, which is somewhat above 1,700 deg. F., while the temperature at which the red-shortness appears is about 900 deg. This temperature is indicated by a dull-red color in the usually dark background of a rolling mill, and it also indicates that the metal is too cold to be worked.

The article asserts that the heating and rolling were done in the regular way and all the ingots treated alike. In practice this is certainly not the way to show the bad effects of sulphur; hence the tests do not show anything but what might be expected and what is already well known. The danger of a high sulphur content in steel does not lie in working or using it in a regular way, but in an irregular way, such as working the metal when too cold or, what has practically the same effect, overheating a boiler sheet. If samples of the various lots had been rolled or worked at different temperatures or had been reheated and tested, the results would have been different.

Another question suggests itself, and that is the method of sulphurization employed in the tests. It is stated in the article, "The sulphur content of certain ingots from this heat was increased progressively by adding weighed quantities of sulphur to these ingots." The point is: Does the sulphur actually mix and form the chemical combination that produces red-shortness by simply pouring it into the ingot? In a work at hand on the manufacture of iron and steel it is said, "The direct combination of sulphur and iron results when these elements are brought into contact under the influence of heat" and "the higher the temperature employed the lower is the degree of the sulphurization of the products."

If there is any value in these statements, they certainly raise the question as to whether sulphur added in the way the article describes really combines with the steel in such a way as that by which red-shortness is caused. At high temperatures, as in the steel furnace, iron is decarburized; but at the lower temperatures of the cementation furnace it will take up carbon. May it not then be assumed that sulphur may be burned out or absorbed in a similar manner? If this be true, the method of adding the sulphur in the tests may be wrong. Metallurgists tell us that sulphur forms many different chemical combinations under different conditions and temperatures. Therefore, the actual chemical combination that produces bad effects in steel may not have been obtained by the method employed. This, together with the omission of tests at temperatures at which red-shortness occurs, may account for the extraordinary results obtained in the tests.

William Hirst.

Trenton, N. J.

Heating Makeup Water

By placing a coil of 20 pieces of 1-in. pipe 8 ft. long in the path of the gases in the breeching of each of three 275-hp. vertical water-tube boilers and passing the makeup water through the coil, an increase of 11 deg. in the temperature of the feed water has resulted and effected a saving of a little more than 1 per cent. in the fuel consumption. Oil is the fuel used, and the saving is about 400 gal. a day of 24 hr.

The water entering the coil is regulated by a ball float operated valve on the intake side of the coils allowing just enough water to enter them to maintain a predetermined level within the hotwell. The source of supply is an elevated tank, the water flowing by gravity through the coils to the hotwell.

The average temperature of the flue gas is about 450 deg. F.

G. C. Long.

Lakeland, Fla.

Trouble from High Water

During my experience with steam plants, I have found that the trouble from many automatic steam devices not giving the service they should is caused by high water. I have read numerous complaints by engineers of reducing valves that would not regulate accurately.

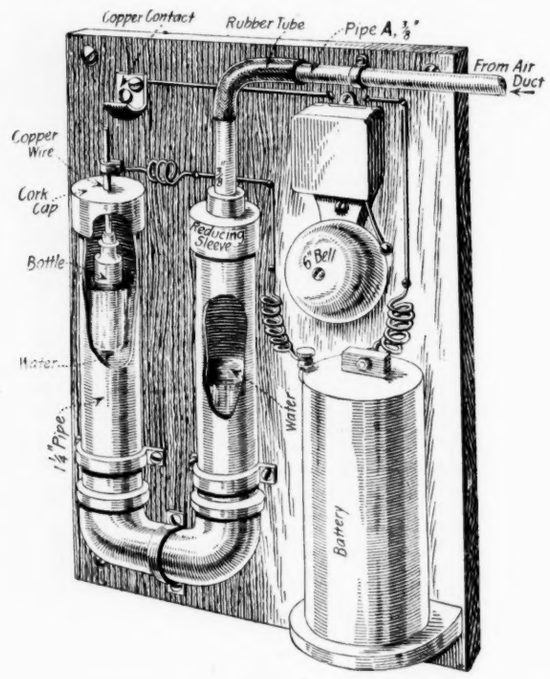
My first trouble of this kind was in an automobile-tire factory where the steam had to be kept at a certain temperature to cure the material properly. The reducing valve used was one of the best on the market. After considerable loss, much worry and work, I found the trouble to be caused by high water carried in the boilers at night, the water bearing quite a lot of foreign matter in suspension. This valve had a close-fitting piston with water-seal grooves which became filled with the grit and caused the piston to stick, and of course the valve would not operate properly. After this discovery the water was carried at the proper level, and no more difficulty was experienced with the valves.

I have since had the same trouble with other valves and also damper regulators fitted with pistons having the water-seal grooves. Whenever they failed to operate, it was found upon taking them apart that these grooves were packed with foreign matter carried over by the water and required soaking in kerosene and thorough cleaning. Keeping the water at the proper level in the boilers is the logical remedy. T. O. Vickers.

Trenton, N. J.

Fan Engine Overspeed Alarm

One of our engines gives trouble at times by exceeding the speed limit. Figuratively speaking, it has often



SPEED ALARM WIRED TO BATTERY

run away. Fortunately it has been stopped before any great damage was done.

This engine is controlled by an automatic shaft governor. It has been through a fire and some of its parts are badly warped, especially the governor wheel, and owing to its twisting motion it seems impossible to keep the governor in order as there is something invariably breaking or working loose. Part of the engine's duty is to drive a blower that supplies air to five boiler furnaces. The engineer in charge has other duties that take him just out of the engine room occasionally.

The sketch illustrates a device I have in use for the purpose of notifying the engineer when the engine exceeds the speed limit. The apparatus consists of a 6-in. electric bell, six dry batteries, 20 ft. of annunciator wire, two pieces of 1¼-in. pipe 8 in. long, one return bend, a couple of caps and an ordinary 4-oz. round glass bottle.

This U-gage is partly filled with water. A pressure of air from the main air duct is supplied through the pipe *A* and is maintained on the surface of the water in the right leg. This action causes the float to rise in the left one, bringing the contact terminals within ⅛ in. of each other. In case the engine overspeeds, the air forces the water to a higher level in the left leg, and the bottle contact closes the circuit, thereby ringing the bell and notifying the engineer of the impending danger. On account of the water in the gage evaporating, it is necessary to add a little every day or so. Outside of this the apparatus requires no attention. J. W. Dickson.

Memphis, Tenn.

Synchronizing Alternators

I would like to question what is set forth as good practice by Thomas M. Gray in an article on synchronizing alternators, *Power*, July 18, 1916. Mr. Gray's first statement is to the effect that he synchronizes by watching for a certain point or pressure on the receiver gage. In using a method like this, is there not danger of the gage becoming stuck? In other words, is it a perfectly reliable way? He next speaks of using the throttle to bring the two machines together. In general is not the governor control used for this purpose?

He concludes by saying: "In fact, after the synchronizing plugs are placed in their respective places, the needle barely makes one revolution, and many times, owing to ideal load and steam conditions, the needle on the synchronoscope does not move from its neutral position, thus showing that the two machines are in perfect synchronism." In the central station in which I am employed only what is believed to be the best methods are used in both the steam and electrical end. No operator in the place would think of throwing a machine in with a dead needle, as it shows us nothing about the relation of the two machines. For instance, if the needle is at the neutral point the machines may be in synchronism in phase, or they may be in synchronism 180 electrical degrees out of phase. Then again the synchronoscope may be broken, in which case it would not move at all. In Timbie and Higbie's new book, "Alternating-Current Electricity," second course, pages 78 to 86, the subject of synchronizing is taken up to some length by the use of lamps instead of an instrument, but the results would be the same in either case. Therefore it would seem to be the correct practice to follow the safety-first rule and waste a few seconds turning the needle around than take the chance of burning up some thousands of dollars' worth of equipment. Harry E. Erskine.

Middletown, Conn.

Inquiries of General Interest

Receiver of Cross-Compound Engine—Why is a receiver necessary with a cross-compound engine? T. R. W.

Engines of this kind usually have the crank of one side set at 90 deg. with the crank of the other side, and one piston is at about midstroke while the other is at the end of its stroke. Therefore, during one-half of the exhaust stroke of the high-pressure cylinder no steam is admitted to the low-pressure cylinder, and a receiver is necessary for storing the steam.

Pump Pipe Sizes—What is the rule for the sizes of the suction and discharge pipes for steam pumps? W. R. S.

The velocity of the water in the suction pipe should not exceed 240 ft. per min. and that in the discharge pipe 300 ft. per min. Hence where G = the number of gallons pumped per minute, the diameter of the suction pipe in inches = $\sqrt{0.1G}$ and the diameter of the discharge pipe in inches = $\sqrt{0.08G}$.

Use of Firebox Stay-Bolts in Vertical Boiler—Why are stay-bolts used in the water-leg of a vertical fire-tube boiler? L. L.

When the furnace sheet of a vertical fire-tube boiler is of lap-riveted construction and of ordinary thickness in proportion to the dimensions of the firebox, maintenance of true cylindrical form is uncertain and it is necessary to stay the firebox sheet to the shell to guard against collapsing of the firebox from pressure in the water-leg of the boiler.

Drawbar Horsepower—What is meant by the term "drawbar" horsepower and how is it applied? R. G.

The term is used to signify the net rate of energy developed by a locomotive or other tractor in drawing a load. If, for instance, a locomotive exerts a pull of 2,000 lb. on a drawbar, in drawing a train of cars at the rate of 30 mi. per hr., or (30 × 5,280) ÷ 60 = 2,640 ft. per min., the net development of energy would be at the rate of 2,640 × 2,000 = 5,280,000 ft.-lb. per min., or 5,280,000 ÷ 33,000 = 160 drawbar horsepower.

Hunting of Corliss Engine Governor—What would cause hunting action of a Corliss engine governor? E. J. S.

Continual fluctuation of the engine above and below the mean speed might be due to friction of the moving parts of the governor or its connections, or to use of too heavy oil in the governor dashpot, causing tardiness or failure of the governor balls to assume positions that properly correspond with the load; or the hunting action might be due to irregularity of speed of the governor caused by slippage of the governor belt or driving pulley.

Air Chambers on Feed Pumps—Why are not air chambers used on duplex as well as on single direct-acting steam pumps for feeding boilers? L. L. S.

When the valves of a duplex pump are properly set, one side of the pump reverses while discharge is taking place from the other side. This results in a continuous motion of the water flowing in the discharge pipe, and although the velocity of the water is not uniform, the shocks from reversals are so slight that, for ordinary sizes and speeds of duplex feed pumps, air chambers are unnecessary.

Exhaust-Steam Injectors—What are the advantages and disadvantages of using exhaust-steam injectors for boiler feeding as compared with employment of live-steam injectors? B. J. M.

The principal advantage is the utilization of exhaust steam for heating the feed water without employment of a feed-water heater and saving the heat lost by radiation from a live-steam injector. The principal disadvantages are that oil contained in the exhaust used for operation of the injector is carried into the boiler, and exhaust injectors cannot be operated with a suction lift of the feed water; also that the water supplied must not be above about 90 deg. F. and the pressure fed against cannot exceed about 90 lb. per sq.in., though with a supplementary jet and cold feed water, special forms of exhaust-steam injectors will feed against pressures up to 150 lb. per sq.in.

Percentage of Energy Realized by Engine—What percentage of energy contained in the fuel is realized by an engine that uses 25 lb. of steam per indicated horsepower per hour, if the mechanical efficiency of the engine is 92 per cent. and the boiler evaporates 8 lb. of water per pound of coal and the coal contains 12,000 B.t.u. per lb.? R. B.

With an engine consumption of 25 lb. of steam per indicated horsepower per hour and 92 per cent. efficiency, the fuel consumption would be 25 ÷ (8 × 0.92) = 3.3967 lb. of coal per actual, or brake, horsepower per hour, containing 3.3967 × 12,000 = 40,760 B.t.u. As one B.t.u. is equivalent to 778.104 ft.-lb., the coal used per hour would contain 40,760 × 778.104 = 31,715,519 ft.-lb. of energy. A horsepower is the development of 33,000 ft.-lb. per min., or 1,980,000 ft.-lb. per hr., and therefore the engine would realize $\frac{1,980,000}{31,715,519}$, or 6.24 per cent. of the energy contained in the fuel.

Actual Suction Lift Not Derivable from Theoretical—What is the suction lift of a pump used for raising water from a well if a gage placed on the top of the vertical suction pipe shows 24 in. vacuum when the pump is in operation? R. P.

Assuming the temperature of the water to be about 50 deg. F., 1 in. of vacuum, or of an unbalanced column of mercury or its equivalent, would be equal to about 1.132 ft. head of water, and the theoretical suction lift would amount to 1.132 × 24, or 27.16 ft. head. But the actual suction lift would be less, for part of the atmospheric pressure that causes the water to rise in the suction pipe is expended as velocity head to set the water in motion, as head in overcoming friction at the entrance of the suction pipe, and for raising the foot valve when one is employed, and as head lost in overcoming the friction in the suction pipe and in bends. Under ordinary working conditions these losses absorb 5 to 10 ft. of the suction pressure head and an estimate of the actual suction lift from the theoretical would be unreliable.

Relative Heat per Cubic Foot of Dry and Wet Steam—What is the relative total heat per cubic foot of dry saturated steam at a pressure of 80 lb. gage, and of steam at the same pressure containing 10 per cent. moisture? W. H

Dry saturated steam at a pressure of 80 lb. gage, or 95 lb. absolute, contains 1,185.4 B.t.u. per lb. and has a specific volume of 4.65 cu.ft. per lb., and therefore contains 1,185.4 ÷ 4.65 = 254.9 B.t.u. per cu.ft. The temperature of steam at that pressure and of the water which may be entrained is 324.1 deg. F., and the density of the water would be 56.54 lb. per cu.ft., or have a volume of $\frac{1}{56.54}$ = 0.01768 cu.ft. per lb. The heat of the liquid is given by the steam tables as 294.5 B.t.u. per lb. If the steam consists of 10 per cent. moisture and 90 per cent. dry saturated steam, it would have a volume of (4.65 × 0.90) + 0.01768 × 0.10) = 4.20 cu.ft. per lb., and would contain (1,185.4 × 0.90) + (294.5 × 0.10) = 1,096.31 B.t.u. per lb., or 1,096.31 ÷ 4.20 = 261 B.t.u. per cu.ft., so that the wet steam would contain about 2.4 per cent. more heat per cubic foot than the dry saturated steam.

Equivalent Evaporation—With the feed-water temperature at 180 deg. F., a boiler evaporated 9 lb. of water per pound of coal into steam at 120 lb. gage, containing 10 per cent. moisture. What was the equivalent evaporation from and at 212 deg. F. per pound of coal? R. C. N.

The whole of the water had to be heated to the boiling point corresponding to 120 lb. gage, or 135 absolute, and only 90 per cent. received the latent heat of evaporation. Referring to Marks and Davis' steam tables, it is seen that for the temperature corresponding to 135 lb. absolute the heat of the liquid is 321.7 B.t.u. above 32 deg. F., and the latent heat of evaporation is 869.9. Therefore, 1 lb. of wet steam at 120 lb. gage with 10 per cent. moisture would contain 321.7 + (869.9 × 0.90) = 1,104.61 B.t.u. above 32 deg. F. With the temperature of the feed water at 180 deg. F., each pound of the feed water would contain 180 — 32 = 148 B.t.u. above 32 deg. F., so that each pound of water received 1,104.61 — 148 = 956.61 B.t.u. The latent heat of evaporation, or heat required to evaporate 1 lb. of water from and at 212 deg. F., is 970.4 B.t.u. Hence, the factor of evaporation was 956.61 ÷ 970.4 = 0.9857, and an evaporation under actual conditions of 9 lb. of water per pound of coal would be equivalent to the evaporation of 9 × 0.9857 = 8.87 lb. of water from and at 212 deg. F.

The Restoration of Service After an Interruption*

SYNOPSIS—The author explains a scheme for opening the generator oil switch only in case of trouble within the generator, and the effects of opening the field circuits on all the generators for a short period in case of trouble on the system.

Generally speaking, alternating-current generators cannot be injured by overloading for a few minutes. Since the sudden interruption of a circuit carrying heavy currents tends to produce abnormal voltages, it is advisable during abnormal conditions on an electrical system to keep all the switches closed, except when the opening of a switch or switches is necessary in order to disconnect some section of the system that has become permanently disabled. Especially is this true when we consider the delay usually experienced in restoring service on a part of a system that has been temporarily cut out, even though there may have been no trouble on that part.

Since the extent of service affected by the opening of a switch is in proportion to the nearness of the switch to the generator, the importance of keeping the switches closed increases as we approach the generators. Consequently, the generator switches should be arranged so that they will never open due to any overload, however great the current may be. But for the chance of trouble within the generators themselves the switches controlling them would be better made nonautomatic. However, with such an arrangement, in case a short-circuit or a ground occurred within the generator the service would be seriously disturbed until the operator could open the switch by hand, and there would also be a possibility of the generator being seriously damaged, if not destroyed.

A consideration of Figs. 1 and 2 will explain the fundamental idea of an ideal scheme for the protection of generators. In Fig. 1 is shown a single-phase generator A with two current transformers B and C connected in series in one leg of the circuit and short-circuited. Connecting the generator to a load L will cause a current to flow in the secondaries of the transformers, the value of which will depend upon the current flowing in the primaries. If the transformers have the same ratio and a connection is made between them as indicated by the dotted line S, no current will flow through it, for the current will have to be of the same value through each transformer. Consequently, if current from the secondary of B flows up through the connection S, the same value from C will have to flow down through S, which is impossible. Therefore, the current will continue to flow in the path indicated by the arrow-heads.

In Fig. 2 is shown the same arrangement as in Fig. 1, except that a load of 5 amp. has been connected between the two transformers. This makes a load of 15 amp. passing through the primary of transformer B and 10 amp. passing through transformer C. If it is assumed that the ratio of the transformers is 1 to 1, the secondary of B will have 15 amp. in it and that of C, 10 amp. The difference between B and C (5 amp.) will flow through S, as indicated.

The generator in Fig. 3 is three-phase, but in describing the scheme of protection only one phase need be considered, as the action of the others will be the same. At each extremity of phase A there is a current transformer, C being near the oil switch and transformer B being, in this case, near the neutral, so that any current passing completely through phase A will produce in the secondaries of the two transformers currents that are exactly equal and in phase, as in Fig. 1. If a relay circuit such as D is connected between the two wires connecting the transformers, and its contracts are connected to both the trip coil of the oil switch in the armature circuit and the trip coil of the switch in the field circuit, the terminals of the relay coil are then connected as circuit S in Figs. 1 and 2. Therefore, as long as the current is the same in each current transformer, no current will flow through the coil, regardless of the load on the generator or whether it is operating as a generator or a motor. Consequently, as long as there is no trouble in the generator, there will be no tendency to trip the switch.

*Revised from a paper read by F. E. Ricketts at the thirty-third annual convention of the American Institute of Electrical Engineers held in Cleveland, Ohio.

Suppose a short-circuit occurs between phases A and B, as indicated by the dotted line S. This will cause a greater current to flow in the primary of transformer B than in C. Then for the same reason as explained in Fig. 2 a greater current will be flowing in the secondary of transformer B than in C. The difference between B and C will flow through the relay coil D, just as the difference between B and C in Fig. 2 flowed through the connection S, which will cause the relay coil to close its contacts and instantly open both the armature and field circuit, thereby not only preventing current

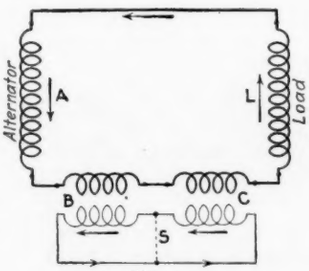


FIG. 1

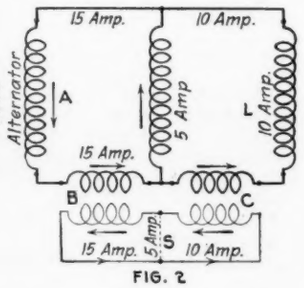


FIG. 2

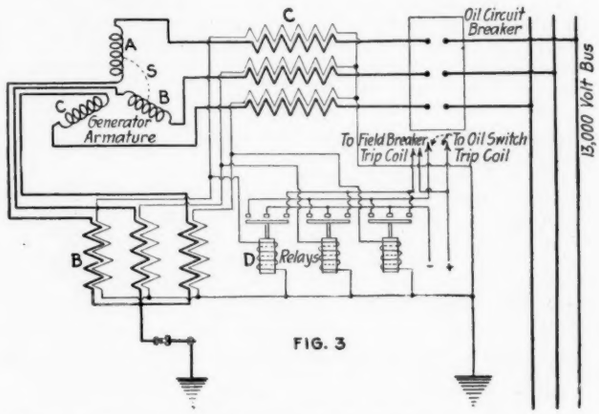


FIG. 3

FIGS. 1 TO 3. SHOW SCHEME FOR PROTECTING AN ALTERNATOR IN CASE OF INTERNAL TROUBLE

from feeding from the bus into the damaged generator, but also preventing the injury that would have been done to this machine by the current generated in the windings, had the field circuit remained closed.

Now the generator switches are arranged so that they will not open on overload, so long as the generator is in working condition, and the other switches on the system are assumed to be equipped for selective operation. Consider what will happen if, when an arc occurs between two conductors of the system at a point where the insulation will not be permanently impaired, if the field circuits of all the generators are simultaneously interrupted for a short interval of time; say one or two seconds. When the field circuits of the generators are opened, the voltage of the system will very quickly drop to nearly zero. Especially is this true when the short-circuit is severe, in which case the heavy armature current will tend to demagnetize the fields, even before the field circuits are opened. This drop in voltage will be much more rapid than could be accomplished by reducing the voltage applied to the field circuits while the field circuits remain closed, since then, as the magnetism of the fields decrease, there would be induced in the closed field circuit a voltage that would oppose the decrease in field current.

If the exciter voltage was lowered by cutting resistance in the exciter field, the time would be still longer. By the time the fields close, the arc will have ceased; and as the current builds up in the fields, the armature voltage will rise gradually from zero to normal, with total absence of voltage surges and an armature current not exceeding 200 per cent. normal. As the armature voltage rises to normal, the service on the entire system will be restored. However, to accomplish the best results, special arrangements of relays should be provided. When there are synchronous motors on the system, special features should be incorporated in their design.

Universal Craftsmen's Convention

The fourteenth annual convention of the Universal Craftsmen Council of Engineers was held at Pittsburgh, Penn., Aug. 8 to 11, with headquarters at the Fort Pitt Hotel. In the assembly room on the second floor of the hotel the delegates held their meetings, while the exhibitors displayed their products in the English room on the main floor. Credit is due G. G. Brown and his hustling local committee for the completeness of the arrangements before and during the entire convention.

On Tuesday morning at 9 o'clock the exhibition hall was officially opened. Twenty-eight exhibitors occupied booths, and twenty other firms used signs as an advertising medium. The engineers adjourned to the assembly room at 10 o'clock, where the preliminary exercises of the convention were held. George G. Brown occupied the chair. Grand Chaplain P. H. Early gave the invocation, and the chairman then introduced H. M. Irons, city solicitor, who appeared for the mayor to welcome the conventioners to Pittsburgh. Charles F. Siegrist, grand worthy chief, responded. Col. Daniel Ashworth dwelt upon the features of Pittsburgh and hoped that the visitors would avail themselves of the opportunity to see as many of its attractions as possible. Frederick C. Rommel, grand historian, gave an interesting address on fraternalism. The delegates then went into executive session, and after the various committees were appointed an adjournment was taken until Wednesday morning.

On Tuesday afternoon there was a sight-seeing automobile trip through the city and to Schenley Park. Wednesday noon special cars conveyed the conventioners to the plant making "Heinz' 57 Varieties." After partaking of an appetizing luncheon, the visitors were shown through the various buildings. A souvenir fan was presented to each lady and watch fobs to the men.

In the evening a musicale was given at the hotel. The entertainers were S. D. Will, piano selections; Smith and Lawson, Independent Brewing Co., vocal and instrumental music; The Imperial Quartette; Mrs. Mary Caldwell, Garlock Packing Co., soprano solos; S. A. Beaton, Pittsburgh Gauge and Supply Co., Scotch songs; Walter Mears, Pittsburgh public schools, tenor solos; Jack Armour, "Power," numerous stories and recitals.

On Thursday noon an excursion was made on the steamer "Sunshine" to the plant of the National Tube Co. An inspection of one of the main buildings proved instructive. Souvenir song books were given out by the company. Refreshments were served en route. The ladies held a card party at the Fort Pitt Hotel on Thursday evening, and the opposite sex joined in a smoker at the Rogers Building. Both were thoroughly enjoyable affairs.

On Friday morning the annual memorial services were held, and in the evening there was a banquet and dance in the main dining hall of the hotel. There were several interesting addresses at the dinner, interspersed with some good entertainment. Charles F. Siegrist, grand worthy chief, was toastmaster.

The election of officers at the last session of delegates resulted as follows: Charles F. Siegrist, past worthy chief; Nathon J. Burdick, worthy chief; H. E. Terry, assistant worthy chief; F. M. Townsend, treasurer; Thomas Jones, secretary; Frank Conroyd, grand warden; John Moore, grand guard; P. H. Early, grand chaplain; Andrew Benner, W. G. Warfield and O. Y. Williams, grand trustees.

Charles F. Seigrist, the retiring worthy chief, was presented with a handsome silver service, the gift of the delegates. The ladies of the local committee each received a suitable present from the visiting ladies. The presentation speeches were made by Robert Ingleson and Mrs. Robert Ingleson respectively.

Toledo, Ohio, was selected as the next convention city in August, 1917.

UNIVERSAL CRAFTSMEN AT THE PITTSBURGH CONVENTION

Fatal Boiler Tube Failure

One or more tubes ruptured in a 300-hp. boiler, under 150 lb. pressure, at the power plant of the Western Ohio electric lines at St. Marys, Ohio, July 24. Two men were killed and several others severely injured. Serious delay was involved in shutting off the steam by hand from the disabled boiler before the injured men could be rescued from the scalding bath.

This is reported to be the first serious accident in this plant, which has been in continuous operation since the early nineties. New tubes had been put in about 15 months ago, and the boiler was considered to be in first-class condition. The cause of the failure is unknown.

ENGINEERING AFFAIRS

The American Society of Safety Engineers will hold its next meeting on Aug. 30, at 8 o'clock, in the Engineering Societies Building, 25 West 39th St., New York. Technical matters will be considered, with a smoker afterward.

The Stevenson Association, No. 44 of the N. A. S. E., held its eighteenth annual outing at Midland Park, Staten Island, on Sunday, Aug. 6. There were a baseball game and outdoor sports of all kinds, with suitable prizes for the winner of each event. The attendance was unusually large, over 500 being seated at dinner.

Phoenix Association, No. 24, N. A. S. E., held its twenty-sixth annual outing at Donnelly's Boulevard Hotel, College Point, L. I., on Sunday, Aug. 13. There was the usual large attendance. The afternoon was devoted to a baseball game between the Engineers and the "Bunch," which resulted in a victory for the latter by the score of 5 to 4, and a program of outdoor sports.

Flywheel Explosion—The flywheel of a new crude-oil engine at the plant of Henke's Artesian Ice and Refrigerating Co., Houston, Tex., suddenly let go on the evening of Aug. 7. One man was injured, the engine was partly wrecked and the breaking of an ammonia pipe resulted in considerable damage. The engine had just been installed and was being adjusted by a mechanical expert from the manufacturing company when a temporary loss of control permitted the engine to speed up sufficiently to cause the rupture.

The American Chemical Society will hold a meeting in conjunction with the Second National Exposition of Chemical Industries, in New York, Sept. 25 to 30. Dr. Chas. H. Herty, of the University of North Carolina, president of the American Chemical Society, will open the exposition on Monday, Sept. 25, at 2 o'clock. The first general session of the American Chemical Society will open at Columbia University on Tuesday morning, Sept. 26. The American Electrochemical Society will open its meeting on Thursday, Sept. 28. The lecture hall of Grand Central Palace and Rumford Hall in the Chemists' Club building will be occupied each afternoon by one or other of the different divisions for the discussion of industrial topics of present-day interest to chemists.

PERSONALS

Rhea H. Robinson, until recently connected with the Economy Fuse Co. at Chicago, has gone with L. V. Estes, Inc., of the same city.

A. L. Hoerr, steam and hydraulic engineer of the National Tube Co., has been appointed chief engineer of the works to succeed George T. Snyder.

Henry W. Crowell, formerly with the Eureka Air Compressor Co., Inc., at Montclair, N. J., is now with the Otis Elevator Co. at New York.

Laurence Meharg, formerly mechanical engineer with the Allis-Chalmers Manufacturing Co. at Philadelphia, Penn., is now with the Hazel-Atlas Glass Co. at Washington, Penn.

Paul E. Good, formerly mechanical engineer of the Southwark Foundry and Machine Co. at Philadelphia, Penn., has accepted a position with the Rateau-Battu-Smoot Co., of New York.

John W. Morton, formerly connected with the designing department of the McIntosh & Seymour Corporation at Auburn, N. Y., is now chief draftsman of the Baltimore Oil Engine Co., of Baltimore, Md.

George S. Wheatley, until recently instructor of mechanical engineering at the University of Pennsylvania, Philadelphia, has become associated with the Cambria Steel Co. at Johnstown, Penn., in the steam-engineering department.

Ambrose Swasey has just been elected to honorary membership in the American Society of Mechanical Engineers. Dr. Swasey's philanthropic work and his achievements in the fields of science and engineering are so well known that repetition is unnecessary. It is certain that no engineer living is more deserving of the distinction. Nor is it the first time that he has been honored for the quality and greatness of his work. In 1900 Dr. Swasey was decorated by the French government with the legion of honor for his achievements in the design and construction of astronomical instruments. In 1905 Case School of Applied Science conferred upon him the honorary degree of doctor of engineering, and five years later he received the honorary degree of doctor of science from Denison University. The doctor was one of the original forty-eight men who were called together in 1880 to organize the society, and during 1904 he was president.

MISCELLANEOUS NEWS

Sauk Center, Minn., has issued $30,000 bonds for an electric-light system.

Bellevue, Iowa—An issue of $14,000 electric-lighting bonds have been sold.

Clark, S. D.—At the special election it was voted to issue bonds for an electric-light system.

Hartland, Minn.—The village contemplates installing an electric-light system. J. A. Halverse is village recorder.

A Large Order for Rotary Converters—The Interborough Rapid Transit Co., of New York City, has placed an order for twelve 4,000-kw. 625-volt rotary converters with transformers with the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn. Each of these machines is capable of carrying a swinging load of 12,000 kw.

General Electric Co. Gives Employees Half a Million—Nearly 9,000 employees of the Schenectady plant of the General Electric Co. have received in the first wage dividend a total of $275,000 as their share of the company's prosperity during the last year.

In all the company paid more than $550,000. Early in the year the General Electric Co. announced that the Board of Directors had set aside a sum of money sufficient to permit the payment of extra compensation to all employees who had been in the service for five consecutive years or more. These extra payments were to be in two installments, the first of which has just been paid. Employees to benefit by this plan drew a sum equivalent to five per cent. of their earnings for the six months ended June 30, 1916. On or before Feb. 1, 1917, they will receive an additional five per cent. of their earnings for the six months ending Dec. 31, 1916.

Government May Use Power at Fort Snelling, Minn.—Great interest is manifested in Minneapolis and St. Paul, Minn., over the instructions given to the Secretary of War vesting him with authority to determine if the Government can use surplus water at Government dams advantageously for public uses before entertaining any offers from private concerns for leasing purposes. The Government is completing a high dam near Fort Snelling, midway between Minneapolis and St. Paul. The Twin Cities together with the University of Minnesota have sought to lease the power developed in excess of minor needs of the Government for lighting the fort reservation buildings. But now there is talk that the Government may establish a $20,000,000 nitrate plant at the old fort. Such a plant would take all the power developed. Hence the cities are shut off from what they had considered a golden opportunity to get cheap electrical energy from the Government.

Recent Legal Decisions

Breach of Warranty of Fuel—In a suit to recover the price of gasoline sold for use as fuel to run an engine in an industrial plant, the buyer is entitled to offset damages by showing the warranty under which the oil was sold, inferiority of the gasoline delivered and notice given the seller with opportunity to make the warranty good. But the seller is not to be held responsible on declarations made by a sales agent after the contract of sale was executed, without proof that they were made within the scope of his authority as such agent. (Alabama Supreme Court, D. J. Meador & Son vs. Standard Oil Co., 72 "Southern Reporter," 34.)

Contributory Fault of Engineer—An award of $3,000 damages in favor of an engineer operating an air compressor, for injuries sustained in using an iron bar to pry the flywheel off dead center while the steam was on, resulting in the bar being thrown with great violence against him, has been reversed by the Pennsylvania Supreme Court on the ground of contributory negligence. He attempted to hold his employer liable on the ground that the bearings of the flywheel had been negligently permitted to become and remain too tight, but the court said: "What can be urged in defense of an engineer of five years' experience who would attempt to lift an engine off a dead center by using a bar between the spokes of the flywheel with the steam turned on, its full energy bound to be applied to the flywheel the very instant the bar had served its purpose in lifting the engine from its dead center?" (Kephart vs. Carbon Steel Co., 97 "Atlantic Reporter," 574.)